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CONSTRUCTION COST KEEPING AND MANAGEMENT

A TREATISE FOR ENGINEERS, CONTRACTORS AND SUPERINTENDENTS ENGAGED IN THE MANAGEMENT OF ENGINEERING CONSTRUCTION

BY

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due to lack of proper instruction or training in engineering management, many engineers do not apply it when they are engaged in construction management.

The science of engineering management involves, therefore, a knowledge of certain elemental principles that control the action of the human mind, combined with a knowledge of methods to be used in applying the principles of the science of mechanics.

In the application of the laws of this new science of management, the first requisite is a record of daily performance of each working unit, whether the unit be an individual workman or a gang of workmen. This recording of the performance of workmen is termed cost keeping. Cost keeping, as we show in Chapter V, is, in our sense of the term, a thing entirely different from bookkeeping. Bookkeeping has been evolved by merchants, and is essentially a system for showing debits and credits. Cost keeping has been evolved by managing engineers, and is essentially a system for showing the efficiency of workmen and of machines. One of the most common blunders arises from attempts to graft a cost keeping system upon a bookkeeping system. The two should be kept entirely distinct, for reasons given in Chapter V.

This is not the first book written on the general subject of cost keeping, but it is, so far as we know, the first book on cost keeping for managers of engineering construction in the field. Cost keeping systems for manufacturers differ quite materially from cost keeping systems for contractors or constructing engineers. The contractor is a manufacturer, it is true, but he manufactures bridges, pavements, sewers, and the like, with a *movable* plant, out in the open air, and, usually, with a gang of workmen picked up for each particular job. The fact that the plant must be installed and dismantled at comparatively short intervals, coupled with the fact that the plant must be frequently shifted as the work progresses, is alone sufficient to modify both methods of management and methods of cost keeping ordinarily used by manufacturers. Weather conditions cause still further modifications.

In no book hitherto published has an attempt been made to present not only methods of cost keeping but the principles of the science of engineering management. The two are so interrelated that it seems best to discuss them as parts of one general subject.

It is, perhaps, not hoping too much that a book of this sort

will be soon adapted for use in the engineering colleges, because, for every engineer who can find employment as a *designer* of machines and structures, there are ten who can find employment as the *managers* of structural operations and plants. As high an order of engineering is required in mastering and applying the laws of engineering management as is required in calculating a stress or in selecting the means to resist it. Moreover, the greatest financial rewards for engineering work go not so often to successful designers as to successful managers. This may not be as it should be, but it is the present condition and seems likely to remain so.

In this connection the authors would suggest that, on certain kinds of work performed by engineering students, each student should be required to report daily his own output. Thus, in field surveying practice, each student should report the organization of the surveying party, the time spent on the different operations, and the amount of work performed. In stadia work, for example, the number of "shots" taken from each station, the time required to take them, and the time to shift the instrument from one station to the next should be reported on a suitable report card. In drafting work, a similar report should be made, giving the area of the drawing, and, if possible, the total length of the individual lines drawn.

Within the last few years a number of engineers have been specializing as traveling instructors, if we may so call them, in cost keeping and management, particularly in the field of manufacturing. Several of these engineers have been astonishingly successful in reducing manufacturing costs; but, what is equally astonishing, they have found it exceedingly difficult to persuade many manufacturers to give them an opportunity to improve existing conditions. The same difficulty confronts the engineer who proposes to reduce construction costs for a contractor. The contractor says to himself: "If this engineer can do all that he claims to be able to do in reducing unit cost, he would not be asking me to employ him, but would become a contractor himself." Reasoning of this sort is fallacious in that it fails to recognize the fact that there is more to any business than a knowledge of *how* to do things. There must also be *means* with which to do. These means are, in many cases, cash capital. In other cases it is an organization of experienced foremen and workmen. Even capital cannot always buy such an organization. Years spent in

weeding out inefficients, and in training men, are required to build up any organization. The intelligent engineer recognizes this fact, and is not too eager to plunge into contracting on a large scale, even if he can secure the necessary capital.

Finally, the world must always have its teachers—men with the natural aptitude and liking for the work of instructing other men how to do things. When this aptitude is strong, a man will frequently care less for a great income, with its attendant worries, than for an opportunity to exercise his talents. This fact is well illustrated in every engineering college, where professors of splendid mental strength devote their lives to training the minds of young men, and do so for a recompense in money that is pitifully out of proportion to the class of work done and to the ability displayed in doing it.

A knowledge of local conditions is often one of the greatest assets of a contractor, and this, too, comes only from years of experience. If an engineer skilled in the science of engineering management can associate himself with a contractor having capital, having an organization, and having a knowledge of local conditions, the result is almost invariably a great reduction in unit costs of construction.

Another obstacle that confronts the management engineer is the belief on the part of the contractor or manufacturer that he himself can develop and install a satisfactory cost keeping system. Often he can; oftener he cannot, for he is apt to be like the man who is his own lawyer and has a fool for a client. In this age of specialization, it is about as much as any man can do to keep up with the developments of his own specialty. This will be particularly the case with management engineering, because it is one of the youngest sciences.

Cost keeping is but a means to an end. The means is the daily report showing what each unit of the organization has accomplished. The end is the economizing of labor and materials, *as a result of the scientific study of the cost reports and of special timing records of performance.* We have italicised the last clause, because this is the thing that is usually overlooked by a contractor who is considering employing a managing engineer.

Cost records of themselves possess some value, but the great value arises from the scientific study of those records. Who will undertake to say that any ordinary manufacturer could have taken the timing records made by Mr. Frederick W. Taylor and from

those records have deduced the methods of producing high speed tool steel that revolutionized a great part of the steel working industry? Here it was that the brains and scientific knowledge of the engineer came into play in interpreting the results of timing records and in developing a great labor saving method.

The word engineer has the same derivative as the word ingenious, as is particularly well seen in the French word for engineer, which is *ingenieur.* It is one of the functions of the engineer to invent—to exercise his talent of ingenuity. This is true of the designing engineer and it is not less true of the managing engineer. It is this very feature of engineering that gives the profession a charm that is irresistible. It leads engineers to spend their lives working more for the benefit of humanity than for their own financial betterment. As a class, engineers are like all inventors, careless of personal remuneration, craving the gratification that comes from having conserved materials or from having increased the output of men. The management engineer, however, is more likely to receive a greater measure of reward for his services than the designing engineer, for the results of his work are more strikingly evident to those who employ him, to say nothing of the fact that he is oftener able to patent devices that he has designed during the process of studying how to reduce operating and constructing costs.

For his efficient and painstaking labor in assisting in preparing cost keeping cards our acknowledgments are due to Mr. Charles Houston.

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THE AUTHORS.

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CONSTRUCTION COST KEEPING AND MANAGEMENT

CHAPTER I

LAWS OF MANAGEMENT

THE SCIENCE OF MANAGEMENT DEFINED, AND THE SCOPE OF THIS SCIENCE

Webster defines the word science thus:

Accumulated and established knowledge, which has been systematized and formulated with reference to the discovery of general truths or the operation of general laws.

A science can not be said to exist until there is enunciated a somewhat comprehensive code of natural laws or fundamental principles. To create a science it is not sufficient to formulate a few principles, particularly if those principles are themselves but corollaries of more comprehensive laws. Nor do a few scientific acts indicate that the acts have occurred because of the conscious application of the laws of a science. Scientific acts occur long before a science is developed. Scientific management has existed from the earliest days of industrial organization. A science of management, however, is of comparatively recent origin.

A scientific law is a formal statement that certain consequences invariably follow certain causes; and, when the consequences and the causes are susceptible of measurement, a scientific law is expressible as an algebraic formula.

A science, then, is a comprehensive code of scientific laws, accompanied by an exposition of the truth of the laws. An exposition of the application of scientific laws is often called an art; but an art may, and usually does, exist prior to the existence of a science.

The science of management may be defined thus:

The science of management is a comprehensive code of demonstrable and formally enunciated laws for so directing the energies of men as to secure the most economic production of utilities.

A management is slightly scientific if it follows only one of the laws of the science of management, and it becomes increasingly scientific as a larger number of the laws are followed. It is not true, therefore, to say that any given management is not scientific, for it is scarcely conceivable that all the laws of the science of management are ignored by any manager. However, there are many degrees of scientific management.

Management consists in directing the energies of men, but, since most human energies are applied through the medium of tools or machines, it follows that management involves study of the efficiency of tools, or machines. The same reasoning leads us to see that scientific management involves a study of every principle of science that relates to the particular class of production under the direction of the scientific manager; for, without such study human energies can not be economized in the greatest degree.

The popular idea attributes to a manager only the art of directly controlling men, and in fact, this is the idea of many who profess to teach and apply "scientific management." The most scientific manager, however, is one who has knowledge not only of the psychological laws that control the action of the human mind, but of the physical laws that limit or assist the mind in accomplishing a physical result.

The science of management usually includes four processes, or steps:

First, supervising the planning of the plant.

Second, supervising the building of the plant.

Third, supervising the operation of the plant.

Fourth, supervising the distribution of the products of the plant.

We use the word plant to denote the tools, machines or devices with which men effect production of utilities, whether the utilities be physical entities or merely work, such as transportation, lighting, etc.

The first process—the planning of the plant—is one that should ordinarily involve more or less inventing, and it is the process that engineers and inventors have had most to do with. In fact, their activities have been very largely confined to the process of planning.

The second process—building the plant—has been mainly conducted by a class of men known as builders and contractors

although there has always been a considerable overlapping of the first and second processes.

The third process—operating the plant—has usually been conducted by "business men," and, until recent years, they have had only the slightest knowledge of the first and second processes. They have been primarily men who could "handle men," whether as employers or as seekers of capital with which to extend their operations.

The fourth process—distribution of the product—has been conducted by salesmen and merchants, who have ordinarily understood very little of the first, second and third processes.

It is clear that a complete science of management must contain laws that apply to every one of these four processes. It is also clear that certain of these laws will be of universal application; that is, they will apply to the manager engaged in designing, to the manager engaged in building, to the manager engaged in operating, and to the manager engaged in selling. It is equally clear that many of the laws of management can be applied only to one or two of the processes. Finally, it takes but little consideration to see that the manager of the first process—designing the plant—must usually possess a considerable knowledge of the three remaining processes, if the greatest degree of economy of ultimate production is to be secured. For example, the engineer who designs a railway should certainly understand the process of building it. It remained for A. M. Wellington to show the engineering world in his "Economic Theory of Railway Location," that the railway locator should also understand a great deal of the process of operating a railway, and the process of marketing its product, which is transportation.

In our estimation, Wellington was one of the greatest teachers of scientific management that the world has produced. Other engineers had appreciated the relation of operating income and expenses to the locating of a railway—and the design of a railway consists largely in its location—but it remained for Wellington to elaborate a science of location founded on the principle that the best location is the one that yields the largest difference between capitalized gross income and the total capitalized cost.

THE LAWS OF PLANT LOCATION AND DESIGN

As stated before, the science of management covers not merely the direct handling of men but the indirect control of all human

activity. Hence any complete discussion of scientific management should include the economic principles to be applied in locating and designing a plant.

Wellington's "Economic Theory of Railway Location" is a scientific exposition of methods to be pursued in locating a steam railway—a plant for producing transportation. Unfortunately Wellington did not enunciate the particular law of scientific management that he sought to apply, but it may be derived by induction, and when so derived it takes this form: *To secure maximum economy so locate and design a plant that the capitalized annual income from its operation shall exceed by the greatest possible amount the total capitalized cost of the plant.*

This may be called the law of plant location and design.

Two terms in the foregoing law may need definition:

To *capitalize* is to divide an annual income or expense by the rate of interest paid for the use of capital.

The *total capitalized cost* of a plant is the sum of its first cost and the amount obtained by capitalizing its annual operating expense.

Thus, if the interest rate is 6% and if the cost of constructing and equipping a plant is \$1,000,000, and if its annual operating expense is \$240,000, we have a "total capitalized cost" of \$1,000,000 + (\$240,000 ÷ 0.06) = \$5,000,000.

It will be noted that the application of this law involves a study of every one of the four processes or steps that occur in producing a utility, that is it involves not only study of (1) planning, (2) building and (3) operating a plant, but (4) selling its product. Prior to Wellington's time, the railway locator had given very little attention to the operating cost and still less to the income from the sale of transportation. Wellington demonstrated that complete scientific control of the process of locating the most economic railway is impracticable without a study of operating expense and of income. Too great emphasis can never be placed upon the importance of this managerial principle, nor can too great credit ever be given to Wellington for his remarkable exposition of it.

This law of plant location and design may be broadened so as to express one of the great fundamental principles of economics. The law as above stated is tantamount to a rule for securing the maximum profit that can be secured by skillful location and design of the plant. But, since the profit made in a commercial

enterprise is augmented by every economy that can be effected, it follows that a plant should be so located and designed that, taken in coordination with other plants from which it receives and to which it delivers products, the total capitalized cost of the coordinated plants shall be a minimum.

A railway, for example, is a transportation plant that acts in coordination with other transportation plants, namely the horses and wagons or motor trucks that deliver produce to the railway and take it away from the railway. Hence the locator of a railway should estimate the cost of hauling produce to the railway and away from it, as well as the cost of hauling on the railway; and he should solve for a minimum cost by so locating the railway as to secure the minimum total capitalized cost of all the coordinated plants—horses and wagons, motor trucks and railway. It is an application of this law in crude form that leads to the location of a railway approximately through the centers of gravity of producing and distributing localities.

Stated in its broadest sense the law of plant location and design is this: *To secure economy so locate and design a given plant that, taken in coordination with other plants from which it receives and to which it delivers produce, the total capitalized cost of the coordinated plants shall be a minimum.*

A wagon road, for example, should be regarded by its locator and designer not merely as a separate plant, but as a plant coordinated with other plants, *i.e.*, horses and wagons, railways, etc.

A factory should not ordinarily be located without careful consideration of the costs of transporting raw materials to it and finished products from it, yet many a factory has been located with very little thought given to these coordinate elements of total cost. Where the materials and product are heavy, such disregard of the law of plant location and design may be fatal to the financial success of the factory.

Once the location of a plant has been scientifically determined, the design remains to be decided upon; and, since this is no longer an element affected by consideration of coordinate plants, we may eliminate that element from the law of location and design, which then gives the law of plant design:

To secure maximum economy, so design a plant as to secure a minimum total capitalized cost, or, its equivalent, a minimum total unit cost of production.

Since it is feasible to express most costs in algebraic form, it is usually possible to derive a formula for the total capitalized cost (or for the unit cost), in which all the constants and variables are correctly given. When this can be done, an engineer will usually find it desirable to solve for a minimum value of the total capitalized cost by the method of calculus wherein the first differential coefficient is placed equal to zero. In this way very simple general formulas or rules may frequently be derived for use in designing plants or plant elements.

It may be said that there is no need of formally stating the laws of plant location and design, since their truth is self-evident when the significance of the language is understood. But that a scientific principle is self-evident when formulated is no reason why it should not be formulated, for prior to such formulation it is usually noticeable that many men frequently fail to apply the principle at all and many others apply it imperfectly. Large factories located at places remote from both raw materials and from markets are so often seen as to make it evident that the business managers who caused their location did not apply the law of plant location. But far more frequently seen than this error in management is the error in plant design that arises from failure to capitalize all the operating cost. Some managers are prone to be unduly impressed by the first cost of a plant. On the other hand, other managers are equally prone to invest too much in plant through failure to capitalize plant depreciation. It can scarcely be said that the foregoing laws of plant design and location need no verbal enunciation when so many instances of flagrant disregard of the laws exist as do exist today. Even self-evident truths are often ignored until dignified by the name of scientific law. This is particularly noticeable in regard to the fundamental law of scientific management, namely that for greatest economy of production the payment for services should be proportionate to the performance. This proposition is so simple as to be almost self-evident; yet it is applied in but the crudest fashion under existing wage systems. Indeed, those who would be the greatest gainers by its application—the members of labor unions—are usually loudest in their protest against the laws of management. We must, therefore, divest ourselves of any idea that the science of management is lacking importance because its laws are readily comprehended, or because some of them are self-evident.

Selection of Plant.—In applying the foregoing to construction work the following rule is relevant. *Use the type of plant which in coordination with other plant units shows the lowest unit costs.*

Giving due weight to the following items:

1. Unit rate of output.

This item may sometimes require the use of "uneconomic" plant, *i.e.*, in order to complete certain parts of a job so that the work as a whole will not be delayed.

2. Cost of operating per unit.

The conditions on the job should be taken into consideration in estimating the unit operating cost.

3. Interest on investment.
4. Depreciation of investment.
5. Cost of installation.

This should include freight, drayage and cost of erecting plant.

6. Cost of moving.
7. Cost of removing.

This item should include cost of dismantling plant, freight and drayage.

We have seen inexperienced builders erect a tower and chutes for concreting a comparatively small building. The cost alone of erecting this tower would more than have paid the cost of placing the concrete by wheelbarrows or concrete buggies. Furthermore the work was not expedited due to shortage in labor and materials, partly due to mismanagement and partly to conditions which, although beyond the control of the contractor, were apparent long before the work started.

An example where a simple-guide hand derrick was used to repair a masonry dam is described in *Engineering News-Record* March 13, 1919 by Charles F. Dingman. The dam, about 3 miles from the city of Willimantic, Conn., is used in connection with the water supply of that city.

Many who saw the work thought that the methods used were old fashioned and inefficient, but they were only adopted after much thought had been given to the relative costs of operating a steam and a hand derrick. The cost of moving a boiler and engine to the work, setting it in place, removing it and returning it to the equipment yard would have greatly offset the probable cost of all the labor of operating the derrick by hand, and it would not have been possible to raise the stones in sufficiently rapid succession to pay for the higher cost of having an engineer constantly

on duty. Furthermore, it was particularly difficult to get coal in this locality.

THE LAWS OF OPERATION

The managing of industrial enterprises, such as construction work in the field, is still an art, and there are few who realize that it can be reduced to a truly scientific basis. Nevertheless, there are certain underlying principles of effective management of men which may be expressed in the form of laws. Application of these laws leads invariably to a greater output on the part of workmen, and this invariability of result proves the scientific basis of the laws. The most important of them can be grouped under their general headings, which are as follows:

1. The law of subdivision of duties.
2. The law of educational supervision.
3. The law of coordination.
4. The law of standard performance based on motion timing.
5. The law of reward increasing with increased performance.
6. The law of prompt reward.
7. The law of competition.
8. The law of managerial dignity.
9. The law of separation of planning from performance.
10. The law of regular unit cost reports.
11. The law of systemic research.

Below are given the main characteristics of each:

The Law of Sub-division of Duties.—Men are gifted with faculties and muscles that differ extremely. One man will excel at running a rock drill, another is better at lifting loads, a third is clever in the application of arithmetic, a fourth is a born teacher—and so through the gamut of human occupation. Moreover, practice serves to accentuate these inborn differences. It is clear, therefore, that the fewer duties any one man has to perform, the easier it is to find men who can do the task well. But give a man many duties to perform, and he is almost certain to do at least one of them poorly, if, indeed, all are not miserably attended to. Hence the following law of management: *So organize the work as to give each man a minimum number of duties to perform.*

This law needs little emphasizing as to its general truth, but it is nevertheless ignored frequently by those who have not applied a scientific treatment to management. Thus, a foreman

is often charged with a multitude of duties. He is expected, for example, to watch the workmen and spur them to action when slothful, to teach his men how to do their work in a more economic fashion, to discover and remedy defects in the machines and tools employed, to plan the arrival of materials at the proper time and in the proper amount, to keep records of daily performance, etc., etc.

Fred W. Taylor was the first, we believe, to urge the subdivision of the duties of foremen and to have what he calls "functional foremen." One foreman, for example, is the machinery and tool foreman. It is his sole duty to study the work done by machines and tools, to effect improvements, to reduce delays, and to supervise repairs.

Another foreman is the gang foreman. His function is to organize the gangs, to direct their operation, and to instruct them in the performance of their work.

A material foreman is employed on large jobs. His function is to confer with other foremen and ascertain what materials, machines and supplies will be needed. He orders the materials, arranges for their shipment, and follows up the manufacturing and railway companies to secure prompt delivery. If necessary, he sends men to the factory, to the stone quarry, or to the freight yard, to see to it that deliveries are made with dispatch. Such a man is often invaluable, for upon him may depend the entire progress of the work.

According to the magnitude of the contract there may be different kinds of foremen, all coming in contact with the same men, perhaps, but all performing different functions. Such an organization as this differs radically from a military organization wherein each man reports to only one superior officer on all matters.

Most industrial organizations today resemble military organizations, with their generals and intermediate officers, down to corporals, each man reporting to but one man higher in rank. There is little doubt that the present tendency in industrial organizations is to abandon the military system to a very large extent, and for the following reasons:

A soldier has certain duties to perform, few in number, and simple in kind. Hence the man directly in command can control the actions of his subordinates easily and effectively. Control

moreover, should come invariably from the same officer, to avoid any possibility of disastrous confusion, and to insure the instant action of a body of men as one single mass. On the other hand, industrial operations do not possess the same simplicity, particularly where men are using machines; nor is there the necessity of action in mass. The military organization, therefore, should be modified to suit the conditions; and one of these modifications is the introduction of two or more foremen in charge of certain functions or duties of the same men or groups of men.

On contract work it is often impossible to subdivide the duties of men to as great an extent as can be done in large manufacturing establishments. The smaller the contract, the less the subdivision of duties possible. In such cases, an approach to the ideal system of subdivision is secured not by employing different men for different purposes, but by a systematic assignment of duties to the same men to be performed at specified hours of the day or days of the week. Thus, a small gang of carpenters is engaged in building forms for concrete, in repairing wooden dump cars, and in framing and erecting trestle work. By timing the men, and by planning their work upon the timing records and the requirements of the work, this carpenter gang can be assigned certain hours or days for each class of work. Thus is avoided the intermittent and uncertain shifting of the gang from one class of work to another, involving not only a loss of time in frequent shifting but a loss of interest in work that is done piecemeal. Moreover, a methodical change of occupation permits a methodical record of the number of units of each class of work performed, and thus leads to the use of the bonus system of payment.

The Law of Educational Supervision.—It is not alone sufficient to give instructions to workmen and foremen from time to time by word of mouth, but the gist of all important instructions should be reduced to written or printed form. Among contractors the pioneer observer of this law is Frank B. Gilbreth, whose "Field System" is a 200-page book of rules for his superintendents, foremen and others to follow. His "Brick-laying System" is another set of rules for the guidance of his brick masons and foremen.

Among manufacturers there are many examples of those who have prepared more or less elaborate sets of rules to be

followed, but the most interesting of these compilations that have come to our attention is the one furnished to its salesmen by the National Cash Register Co. In this book are gathered a vast number of useful hints and practical suggestions and arguments to be used in selling National cash registers. Each possible objection that a prospective purchaser may raise is met with one or more specific answers. This company not only provides its salesmen with a textbook but has a school for training salesmen. At regular intervals all the salesmen meet together and discuss their respective methods of selling cash registers. Any new suggestions that are good become subsequently a part of the book of instructions. Thus the combined wisdom of hundreds of salesmen is preserved and delivered to every salesman that the company employs. This plan is followed also by many of the life insurance companies. Railway companies have long made it their practice to furnish their civil engineers with printed sets of rules for railway location, as exemplified in McHenry's "Railway Location." All these are forms of educational supervision, and some are very elaborate. The small contractor need not necessarily have a printed book of rules of his own making, but he can supplement some such book of rules and hints by a typewritten or mimeographed set of sheets containing the most important of his own instructions. In this manner the repetition of a costly blunder by a foreman or workman can be avoided by a special rule or hint, while a labor saving "trick" can be passed on to other men in the contractor's employ.

In developing a system of educational supervision, the greatest assistance can be obtained from articles in engineering and contracting periodicals, for there will be frequently recorded labor saving methods well worthy of trial by other contractors. In a long article it may be only a small hint that is worthy of being abstracted and placed among the hints for foremen.

In preparing a set of rules and hints, take pains to distinguish sharply between what is a rule always to be followed and what is a hint to be followed optionally. It is well to have a set of *rules*, each with its specific number, and a separate set of *hints*, also numbered.

The second law of management is briefly this:

Secure uniformity of procedure on the part of employees by providing written or printed rules, supplemented by educational suggestions or hints to guide them in their work.

The Law of Coordination.—*So schedule the performance of each gang of men that they will work in perfect coordination with other gangs, either adjacent or remote.*

Perfect coordination involves the working of each man to his capacity all the time. This necessitates not only the organization of gangs of just the right size, but the prompt arrival of standard supplies and materials, and freedom from breakdowns of plant.

An examination of almost any piece of construction work in progress will disclose the fact that most of the men spend a considerable portion of their time waiting either for somebody else to do something or for materials to arrive, before they can proceed. The cause is improper coordination of the work. One gang may have too many men, and therefore may be able to work considerably faster than another, and be continually catching up with it. They will then adopt a slower pace, keep seemingly busy, and manage to kill a large percentage of their working time. These delays are chargeable to lack of coordination, although a careless inspection of the work may seem to indicate that everything is going smoothly. A job can look smooth and at the same time be so badly coordinated as to be uneconomical.

The necessary adjuncts to proper coordination of work are briefly as follows:

1. A carefully drawn schedule of performance.
2. Regular arrival of material and supplies.
3. Prompt and proper repairs to equipment.
4. The proper quality of supplies.

The best method that has so far been devised for making things happen on time is first to prepare a schedule, and then to live up to it as far as the interruptions of the weather and the limitations of human nature will permit. To prepare a schedule properly, it is necessary to know how fast work can be done under the conditions which are to govern it. At the best, there will be a considerable variation to be accounted for by ignorance on the part of the planning department on the one hand, and by the interference of the elements on the other. A form of chart, made on tracing cloth, with various symbols to indicate the kinds of work to be done, has been found very useful. As the work progresses the performance can be checked off on the chart, and thus indicate whether the work is proceeding on time. Where the work is such as that of building construction, and there is

but little storage capacity for materials, it is best to have the chart prepared a considerable time in advance, so that materials will arrive when they are needed and yet not so much in advance of the proper time as to require large storage capacity at the site of the work.

The principal railroads now use, for preparing time tables, a large blackboard on which the locations of stations are represented by ordinates and time by abscissas. Pins, over which are stretched threads of different colors, indicate trains, and the running speed of each train and its direction can be noted at a glance from the angle made by the thread with the horizontal. The principle of this arrangement can well be applied to the preparation of time schedules which can be afterward made up in more permanent form for record. Like the operation of a railroad, but more so, a piece of construction will always be ahead of time or behind time, and some parts may be ahead while others are behind the schedule. For this reason a form of chart which will admit of many alterations and additions is to be preferred to one on which changes cannot easily be made.

On a large piece of contract work it is often not easy to have on hand a very large supply of material, and the progress of the work is thus dependent upon its regular arrival. The man whose business it is to distribute and handle material will have to be placed upon some other sort of work or laid off altogether if the material fail. This can rarely be done without considerable loss of time and impairment of the efficiency of the men. When a man has been handling reinforcing bars until he has become quite proficient in it, when he knows what sizes of bars go in the different elements of the work, and what lengths are called for in different parts of a structure, a portion of the time spent in educating him to this point is likely to be lost if he has to be unnecessarily thrown upon another kind of work, and it is very difficult to tell by ordinary inspection how much loss of efficiency is involved. By shifting men on emergency in this manner it is impossible to keep the work coordinated unless each department has more than its economical number of men assigned to it and a continual process of shifting takes place.

When times are dull and the railroads are not overloaded with business, it is fairly easy to get railroad deliveries on time, by seeing to it that shipments are promptly made; while in times of financial prosperity, when the railroads are congested with freight

some consignees are sure to suffer from tardy delivery. Therefore, under such circumstances, it is essential to have larger stock piles and more storage capacity than when the railroads are not busy.

It needs no argument to demonstrate that a derailed car, or a broken steam shovel, or a wrecked derrick, is a sure obstacle to any proper coordination of the work. The best way to avoid break-downs is to keep the equipment in repair. Every engineman on the job should make a daily report in writing of the condition of his engine when he leaves it at night, and these reports should be filed just as regularly as any other records on the work. It should be the business of some one daily to go over these records and call the attention of the equipment foreman, or some one acting in that capacity, to any trouble which may cause interruptions to the service. Thus the equipment foreman becomes responsible for a large proportion of the break-downs, and he will see to it that these break-downs are as rare as possible.

Poor supplies are likely to cause disarrangement of work. There are few more expensive blunders than that of having the wrong grade of dynamite for rock work, unless it may be to have the right grade in the wrong condition, as when dynamite is frozen.

Bad coal will upset the temper of the blacksmith and of his steel, thus disorganizing the drilling operation sufficiently to cause delays to that and to blasting. Where boilers are worked under an "overload" and require careful nursing on the part of the fireman with good fuel, bad coal will cause a startling falling off in performance and greatly impede the processes involved. A 30-H. P. boiler with the best of fuel may be worked to a 35-H. P. rating, but then come down to a 20-H. P. rating upon feeding it from a shipment of slaty coal.

Systematic inspection of supplies that have been purchased under specification as to quality will eliminate most of this sort of trouble.

A surprising amount of the time of men and machines is spent in almost any work of construction waiting for something else to be done. The cause is improper coordination of work. Now while the law of coordination of work is not the first of the laws of management engineering it is by no means the last as we shall endeavor to demonstrate before we conclude these remarks. Perhaps the initial step toward proof is to exemplify by actual

records how much waste time, delays waiting on some other construction operation may count into. We have such a record at hand in a report of the Isthmian Canal Commission. Besides giving the unit costs of all the major items of construction during the twelve months reported on, this report records the performance of several of the largest plant units employed. Here, we shall confine our attention mainly to the one item of plant delays waiting for the performance of some coordinate task. We find that the total delays to plant and the delays due to "waiting" were, in percentages of the total time the plant was under pay, as follows:

Purpose of Plant	Total delays, %	Delays waiting, %
Rock crushers, Porto Bello	27.34	7.10
Main mixing plant, Gatun	41.26	33.34
Auxilliary mixing plant, Gatun	40.57	37.86
Unloading cableways, Gatun	50.57	24.21
Unloading derricks, Gatun	50.92	26.24
Concrete placing cableways, Gatun	27.04	17.59
Rock crushers, Ancon	25.80	3.15
Sand unloading cranes, Balboa	29.41	26.14
Mixing cranes, Pedro Miguel	27.60	21.39
Mixing cranes, Miraflores	37.75	8.08
Concrete placing cranes, Pedro Miguel	32.56	23.15

Of the 11 plants recorded only one was able to work more than three-quarters of the time it was under pay; two were not able to work half the time they were under pay. Delays of one sort or another consumed from 25.8 to 50.92% of the nominal working time of the plants recorded. Delays, waiting for some coordinate task to be performed consumed from 3.15% to 37.86% of the nominal working time of these plants. In only three cases were delays waiting less than 10% of the time named and in only four cases were they less than 20%.

The vital significance of the figures quoted cannot be easily overlooked, but they nevertheless deserve emphasis. What has been the increased cost of concrete work at Panama, due to these delays? Probably no one can say exactly. No one on the other

hand can doubt that it has been considerable. A cableway, or a derrick or a concrete mixer is not costing quite as much when waiting for work with steam up and the gang standing ready, as it is when actually carrying load but the difference is not very great. Every stoppage of a mixer or cableway or any other tool under pay costs money and adds to the unit expense of production. It being true that delays increase the cost of production then the converse is true that the elimination of delays decreases the cost of production. All delays cannot be eliminated. There will always be breakdowns of machinery and stoppages from other unavoidable causes, and no series of construction operations can be so perfectly coordinated that there will not be some waiting of one on another. Good management, however, can reduce the number of delays due to almost any ordinary cause and every reduction saves money.

Turning to the tabulation of delays given above, attention is directed to the percentages in the column showing delays waiting on coordinate operations. This is a class of delays which is ordinarily susceptible of more nearly complete elimination than most other classes. All of the 33.34% delay of the main mixing plant at Gatun was waiting for cars; the same cause accounts for the 37.86% delay of the auxilliary mixing plant. Waiting for cars and barges accounts for the delays at the cableway and derrick unloading plants at Gatun; waiting for concrete and for forms accounts for the delays to the plants placing concrete. These are all delays due to lack of coordination. To emphasize the illustration still more, let us take the Gatun concreting plant. The cableways unloading sand and stone into the stock piles were idle 24.21% of their time waiting for the barges bringing these materials to the work; the concrete mixers were idle 33.34% of their time waiting for cars bringing stone and sand from the stock piles; the cableways placing concrete were idle 3.8% of their time waiting for concrete cars to come from the mixers and another 13.79% of their time waiting for the forms to be placed which were to receive the concrete. The operations of the barge fleet, the unloading cableways, the material cars, the mixers, the concreting cableways and the workmen erecting forms were not in coordination. It does not concern us here to investigate to what extent this particular example of lack of coordination is excused by the local conditions; the fact sought to be conveyed is that imperfect coordination of sequential

operations is the cause of the major portion of plant idleness at Panama.

The fact that is here shown to be true at Panama will be found to be true on almost any piece of construction work. Workmen and machines spend a considerable portion of their time waiting for something else to be done or for materials with which to work. The various operations required are not in coordination. What are the causes of this lack of coordination? They are many, some of them are unavoidable but most of them can be avoided entirely or in great measure. Lack of a carefully drawn schedule of performance is one cause. There is no time table to guide the performance of the various working units or to disclose when any unit is ahead of or behind time. Another cause is irregular arrival of materials and supplies to the workmen and machines. Failure to keep plant in good repair resulting in the breakdown of a machine upon which workmen or other machines depend is a third cause. Still another cause is improper quality of supplies, poor steel for the blacksmith or poor coal for the boilers. The list of minor causes is much longer, but like those named they are ordinarily all susceptible of being in great measure eliminated.

It has been the pleasure of a considerable number of engineers and a few engineering journals to depreciate the worth of scientific management or management engineering as we prefer to designate it. When plants like those at Panama whose outputs run into the hundreds of thousands of units per year, stand idle under nearly full operating expense and in six cases out of ten for over 20% of their time waiting on some other operation there is certainly opportunity for the exercise of management engineering. And one of the first steps in this work is to do just what has been done at Panama, keep a careful record of plant performance. It is one of the easiest things in the world to misjudge plant performance, particularly where the aggregate output per day or per month is large. The 35,000 to 65,000 cu. yd. output per month of the main concrete mixing plant at Gatun, Panama, seems overwhelming evidence of efficiency until we learn by counting its time that it stands idle 33% of that time waiting for cars supplying it with raw materials.

The Law of Standard Performance Based on Motion Timing.—Nearly every operation performed by a workman involves several motions, although at first sight it may often seem that there is but one.

Frank B. Gilbreth has coined the term "motion study" to denote his method of observing the number and kind of motions made by a man—a bricklayer, for example—in performing a given operation. His plan is to analyze the motions, assigning a name to each motion. His next step is to endeavor so to arrange the supply of materials, the position of tools, etc., as to reduce the number of motions and the distance of each motion to a minimum.

Fred W. Taylor was the first, we believe, to adopt the practice of invariably studying each motion by the aid of a stop-watch. A large number of stop-watch observations not only give the average time of a motion, but, what is of far greater importance, they indicate what the minimum time for each motion may reasonably be expected to be. It then follows that the sum of these minimum times for the different motions represents a standard time of accomplishment of the entire process. Hence our law of motion timing:

In the performance of every process, the sum of the minimum times observed for each motion gives a standard of performance possible of attainment under sufficient incentive.

Harrington Emerson calls this standard of excellence 100%, and has developed the plan of rating all actual performances in percentages. Thus, if the standard time for drilling a 10-ft. hole in a certain rock were 60 min. and, if the actual time were 90 min., this performance would be rated at $60 \div 90 = 66.67\%$.

In establishing a standard time of performance, the first step is to ascertain the unit times upon the work as ordinarily performed. The next step is, by study of the time elements and the local conditions, to eliminate as many motions as possible and to reduce the time of others, either by shortening the path of motion, or by accelerating the velocity of the motion.

To illustrate by an example, we give the following time study, which was made by one of the authors some time ago on some some cableway work. Since this was done the Lidgerwood Mfg. Co. have completely redesigned their cableway engine and fall rope carriers and have introduced new features in control (notably in the Gatun cableways in Panama). Therefore, while the data are correct as history, they must not be taken as indicating the limit of present possibility. A considerable number of studies was made, but one only is given for purposes of illustration:

TABLE 1.—1908 CABLEWAY NO. 2, HANDLING CONCRETE

Process	Observations	Minimum time	Average time	Maximum time	Efficiency	
					Standard time	Per cent.
Rl 40 ft......	30	6.0	10.5	17.3	6.0	57.1
Tl 470 ft......	33	31.0	47.3	63.0	31.0	65.5
Fl 123 ft......	37	22.0	30.8	44.7	22.0	71.5
———D......	37	16.8	61.7	140.4	16.8	27.2
Re 123 ft......	36	19.4	23.7	29.3	19.0	80.4
Te 470 ft......	36	26.5	37.2	64.5	26.5	71.2
Fe 40 ft.......	35	11.0	42.9	96.0	11.0	25.6
———L......	28	12.0	73.2	234.0	9.4	12.8
Totals, 1,266 ft		144.7	327.3	689.2	141.7	

TABLE 2.—1908 CABLEWAY NO. 3, HANDLING CONCRETE

Process	Observations	Minimum time	Average time	Maximum time	Efficiency	
					Standard time	Per cent.
Rl 40 ft......	18	8.0	13.6	18.2	6.0	44.1
Tl 470 ft......	17	35.5	39.3	68.0	31.0	78.0
Fl 123 ft......	21	25.0	39.4	77.0	22.0	55.9
———D......	22	20.0	62.5	119.0	16.8	26.9
Re 123 ft......	22	19.0	28.5	36.0	19.0	66.8
Te 470 ft	22	30.0	46.6	102.0	26.5	56.9
Fe 40 ft......	20	18.0	29.1	48.0	11.0	37.8
———L......	16	38.0	75.6	220.0	9.4	12.4
		193.5	334.6	688.2	141.7	

The first column gives the abbreviations of the processes, distances, etc.; the second gives the number of recorded observations on each process; the third gives the minimum observed time in seconds for each process in that table; the fourth gives the average; the fifth gives the maximum time; the sixth gives the minimum of all the observed times for each process. While this is by no means the shortest possible time in which the process could be accomplished, it is the shortest one observed, and has

here been taken to represent standard (100%) efficiency. By dividing the standard time by the average for each process the average efficiency as observed is obtained. This is shown in the seventh column.

As a result of this time study, it was possible to make an estimate of the probable increase in efficiency that could be obtained by rebalancing the engines. A further improvement was discovered in the method used in signaling to the operator, and an estimate of the saving to be obtained in this manner was made. A further improvement in regard to the position of the operator was discovered. A collateral improvement was perceived in the line of altering the design of the towers, so that the cost per unit of handling materials could be reduced, and further suggestions of a confidential nature, which we are not at liberty to discuss here, were made.

The Law of Reward Increasing with Increased Performance.—*All payments for work should be proportionate to the work done.* This is the fundamental law of economic production. When this law is ignored—and it is partly ignored to-day on practically every class of work—the producer ceases to take keen interest in his work. Under the common wage system of payment, one brick mason receives as much as another, regardless of skill and energy. Individual incentive is lacking, save as it is supplied by fear of discharge. When laborers, working under the wage system, are put at the task of shoveling earth into a wagon, each man seeks to do as little as his neighbor, and the slowest becomes the pacemaker for the rest. Such ambition as any individual may possess is stifled by the knowledge that his increased output will never be known by his employer, and consequently never rewarded. Moreover, an ambitious man in such a gang is chided by his fellows who warn him not to set a "bad example" by working himself out of a job.

The wage system is responsible in the first place for lack of sufficient incentive to good performance, but its vicious effects have been greatly augmented by the stupid actions of many labor unions, such as the restriction of daily output, the limiting of the number of apprentices, the demanding of wages that have no relation whatever to the output of individuals, the refusal to work under foremen who are not also members of the union, the refusal to do any sort of work except that prescribed by the union, and the like. In the long run, all such restriction of out-

put, whether due to the lack of sufficient incentive, or to the rules of labor unions, or to the customs of a country crystallized into castes such as exist in India, lead to a reward commensurate with the output. Summing up: The wage received becomes ultimately proportionate to the output. The high wages prevalent in America are due neither to labor unions, as some profess to suppose, nor to abundance of natural resources, but to the fact that in America labor unions have not thus far greatly restricted the output of individuals except in a few trades, and more particularly to the fact that they have not opposed the introduction of labor saving machinery. In addition, American managers are far in advance of all others in their recognition of the fundamental law of management—namely, that the reward should be proportionate to the performance. Hampered though they have been by the wage system, American managers have been liberal in their policy of payments for work performed. In recognition of his share in the greater output of earth excavation, the steam shovel operator in the United States receives $175 to $250 a month.

Within the past decade still further strides have been made by American managers toward a more effective recognition of this fundamental law of proportionate reward. Various systems of payment, known as the bonus system, the differential piece rate system, and the like, have come into more general use, and even the old piece rate system has received a new lease of life, all tending wonderfully to stimulate the energy and wits of workmen, because they are in accord with the law of proportionate reward.

The average employer will grant instantly that workmen should be paid in proportion to performance, but does the average employer so pay his workmen? Does the man who shovels 18 cu. yd. daily into a wagon receive 20% more pay than the man who shovels 15 cu. yd.? Does the foreman who erects a bridge in 15 days get any greater salary than the foreman who spends 20 days with a gang of the same size on a bridge of the same dimensions?

While the ordinary wage system of payment is crudely based upon the "law of proportionate reward," few will attempt to mantain that it represents a logical application of that law. Certainly the grouping of common laborers into a general class whose wages are, say $2.50 per day, is far from being an appli-

cation of the fundamental law of management, for among these laborers are men varying widely in ability and inclination to work.

When thus confronted with a self evident failure to apply this "self evident" law of management, the average manager will find you forty excuses for failing to follow it. "It is impossible to vary wage without producing dissatisfaction." "Labor unions will not stand for it." "I know that men differ in output and in ability, but I have to work them in gangs and I can't pick out one from another." "You have to take the lean with the fat." "Theories are all right, but there are practical limits to their application." "I get more out of my men than my competitors do out of theirs." These and many other excuses leap to the lips in defense of the pernicious wage system. But we are forced to regard every such excuse as an after-thought, for there is scarcely one of them that does not give you its own answer the minute it is announced.

Dissatisfaction among workmen is either the result of unfair treatment or the evidence of an unsound mind. The normal man is never dissatisfied when given a chance and an incentive to earn more money. It may be that a man has unthinkingly followed the mandates of a labor union and is opposed to a piece rate or bonus system "on general principles." He may tell you that theoretically it is admirable, but that experience has shown that employers invariably cut the rate. If this is the attitude—and note it keenly—the dissatisfaction of the workmen is not with the operating of our fundamental law of management, but with the failure of employers to obey that law. The workman objects not to pay proportionate to performance but to the cuts in the price rate or bonus which short sighted and hoggish employers have so often made.

When a manager excuses his failure to follow the fundamental law of proportionate reward by saying that he must work his men in gangs and that he can not distinguish the relative performance of individuals, there is more reason for considering his excuse, but even then it is an excuse badly in need of crutches. Because men must be worked in gangs on certain classes of work does it follow that one must mingle good, bad and indifferent workmen together in the same gang? Not a bit of it. Every employer who is really keen tries to weed out the poorer workmen, if men are abundant, and secure gangs of more than average

ability. But how often do these same employers then proceed to pay more than average wages? By not doing so they show their complete blindness to this fundamental law of management which they will tell you is so self evident.

The man who starts with a determination to apply the law proceeds along different lines entirely. He first puts his wits to work to devise ways of doing away with gang work entirely, or at least of reducing the number of men in each gang. Thus if a gang of men is engaged in shoveling earth into wagons, the manager is generally able to supply extra wagons and to split up the large shoveling gangs into small groups of, say two men to each wagon. Since extra wagons are provided no lost time occurs while loading them, and it is a matter of no consequence whether a wagon is loaded by two men in 20 min. or by six men in 7 min. The aim is to reduce the large gang to smaller gangs, and to put the best workmen together, so that they can be paid according to their performance. Still further to arouse individual ambition it is often wise to put a dividing board across the wagon box, assigning one-half of the wagon to one shoveler and the other half to his mate.

As a corollary of the fundamental law of proportionate rewards we have this:

Group men in gangs according to their respective energies, and so plan the work as to make each gang as small as is consistent with efficient work. Then pay these gangs according to the number of units of work done by each.

There are many classes of work that do not admit of working men in small gangs, to say nothing of working as individuals, but the scientific manager will still persist in his efforts to group men according to their energy. If laborers are scarce, he will not discharge the poorer ones, but will group the poorer workers together and pay them less than the other groups of greater ability. But if laborers are plentiful, he will speedily weed out the poorer workmen, keeping only those who earn large incomes by virtue of their large output.

In any event, even where large gangs must be worked, payment of men should be based upon performance. Taking steam shovel work, for example, how often does one see anything given to the men except the standard wages? Yet every man of the various gangs, from the pit men to the men dumping the cars, is a factor in the total yardage moved. Once the character and

condition of the work are fairly well known a scientific manager will establish a bonus on every yard in excess of a stipulated minimum, and this bonus will be distributed among *all* the men, prorated according to daily wages. A special bonus should be given to the foreman (not pro rata), for upon him rests the display not merely of energy but of foresight. His reward should therefore be exceptionally large if exceptional output is secured.

Where several different gangs of men are dependent upon one another in securing a result, the problem of providing a reward proportionate to performance is obviously complicated. Take macadam road building, for example. There we have a gang of quarry men, another gang delivering rock to the crusher, a gang on the crusher, a gang hauling, and a gang spreading, sprinkling and rolling the stone. If the gang on the crusher is slow, an output of only 50 cu. yd. per day may result. Then the teams hauling the stone are unable to perform a satisfactory ton mileage of work, and the gang spreading and rolling is unable to do a good day's work. How can a manager pay bonuses to these separate gangs in a manner satisfactory to each? The square yard of macadam may be the unit in which the contractor receives his pay, hence his tendency will be to establish a bonus based upon the number of square yards laid daily. However, to do so is an error. The rock drillers should receive their bonus upon the number of lineal feet of hole drilled. The men who handle the rock should receive their bonus upon the yardage of loose rock crushed. The teamsters should be paid a bonus upon the ton miles or yard miles. The spreading gang should receive their bonus upon the cubic yards spread. The roller engine man should receive his bonus upon the number of miles his roller travels daily. In each case the effort should be made to select for each gang a unit of work that most closely corresponds to the theoretical unit of mechanical work—namely: resistance multiplied by distance. In rock drilling this unit is the lineal foot of drill hole. In hauling, it is the ton mile. In rolling, it is the roller mile.

The *result* of these various units of work is the square yard of macadam, but the square yard of macadam is not the proper unit for measuring the work done by any single gang, excepting perhaps the gang engaged in spreading.

The work of a steam roller is commonly reported in terms of

the number of square yards of macadam compacted daily. Nevertheless this is a very unfair unit. On a compact gravel subgrade a steam roller is capable of daily consolidating several times as many square yards of macadam as on a sandy subgrade. Double the amount of water used to puddle the screenings and the roller will greatly increase the yardage consolidated. In brief the roller engine man has many more trips to make of a given length of road where the subsoil is soft, and where water is meagrely supplied. His work is more truly measured in the miles he travels than in the area he consolidates daily.

If the average manager of macadam road work realized this fact we should see several decided changes in current practice. First the 10-ton roller would speedily give way to the 15-ton roller having proportionately wider tires and the same weight per lineal inch of tire, for one mile traveled by such a 15-ton roller is the equivalent of 1½ miles traveled by a 10-ton roller. Second, the engine man would use the high speed instead of the low speed, and compact a correspondingly larger area per day. Third, the water tank on the roller would always be made large enough to enable the roller to run 5 hr. continuously, even when working on steep grades. Fourth, the engine man would see to it that no stops to take on water would occur except at the noon hour and at night. Fifth, the engine man would have his roller steamed up the moment that the working day began. Sixth, the engine man's every effort would be directed toward making a big mileage, and he would be quick to complain of poor coal or of anything that in the slightest degree reduced his mileage.

Result? Twice as many trips over the macadam as needed? Precisely—and then what? Twice as much broken stone delivered daily to be consolidated by the roller. The first result of paying an engine man a bonus upon the mileage covered (using an odometer to measure mileage) is to stimulate him to an overproduction of mileage, which he should be paid for just the same as if it were needed. The next step is to utilize that mileage by increasing the amount of stone delivered daily.

Now it may be said all this could be accomplished in other ways. How? Who has accomplished it otherwise? There is no stimulus comparable to the stimulus of paying men in terms of the best theoretical unit of work. The mile for the roller, the lineal foot of hole for the rock drill are units of this sort.

Now let us go a step farther. If a man is ready to work but has nothing to work with, what shall be done? Is it sufficient merely to pay him an hourly wage while he lies idle, and let him lose his possible bonus? We think not. *We favor paying him for every hour of idle time on the basis of the total earnings he averages per hour when actually working.* At first this seems like an undue penalty upon the contractor for delays due to accidents. But we believe that the penalty for breakdowns and delays should be severe. Then those who are responsible for the accidents and delays will receive the punishment they deserve—the punishment that will quicken them to scheming how to escape it in future. We have found it a good plan to dock the wages of the engine man on a crusher a dollar for every hour lost through shutdowns in excess of three hours per week, and to give a bonus of a dollar an hour for all time saved from the three-hour standard of loss. An engine man who had been losing nearly an hour a day for one reason or another, woke up when he was informed that this rule was about to go into effect. He had come to regard short stoppages as being a matter of course until it also became a matter of course that he should settle for such delays out of his own pocket, at least in part. One of the sprocket chains on the bucket elevator had been in the habit of breaking almost once a day. The engine man, who was an intelligent fellow, had blamed it upon poor material in the chain, too light a chain, and what not. But now he began to think. Thinking, he concluded to experiment a little. Perhaps the chain was too tight, and when a bit of stone flew out and caught between the chain and the sprocket wheel there was not enough slack in the chain, so perhaps that was why it broke occasionally. The surmise was perfectly correct. Why some of us, who also had intelligence, had not thought out the reason for the breakages of the chain I do not know, unless it is that we had many another thing to think about. By giving the engine man one thing to think about and a very strong incentive for hard thinking the trouble was speedily located.

Using a somewhat long story to illustrate a conclusion, we thus come to another corollary of the fundamental law of management:

Pay men for lost time not upon the basis of the hourly wage but upon the total hourly earnings (including the average bonus), and place a heavy penalty for lost time upon the man who is responsible

for it, at the same time giving him a bonus for reducing lost time below a stated standard.

Sometimes the responsible individual is an engine man, sometimes a foreman. Sometimes a whole gang should be made responsible.

If men are to be paid a bonus for excellent performance, it is but logical that they should incur a penalty for carelessness, and even for lack of quick wittedness. In the operation of machines there always will be some lost time, but there now is vastly more than there should be, and the real reason is to be found in the absence of sufficient incentive to reduce the delays.

The Law of Prompt Reward.—Any reward or punishment that is remote in the time of its application has a relatively faint influence in determining the average man's conduct. To be most effective, the reward or punishment must follow swiftly upon the act. Hence a managerial policy that may be otherwise good is likely to fail if there is not a prompt reward for excellence. Most profit-sharing systems have failed, principally because of failure to recognize the necessity of prompt reward, as well as because of failure to recognize the necessity of individual incentive.

The lower the scale of intelligence, the more prompt should be the reward. A common laborer should receive at least a statement of what he has earned every day. If, in the morning, he receives a card stating that he earned $3.10 the previous day, he will go at his task with a vim, hoping to do better. But if he does not know what he has earned until the end of a week, his imagination is not apt to be vivid enough to spur him to do his best.

A daily or weekly statement of earnings, followed by prompt payment, is a stimulus essential in securing the maximum output of workmen.

The Law of Competition.—The pleasure of a competitive game lies in conquering an opponent, and this follows logically from the fact that competitive games are an evolution from the primitive chase or battle. Work conducted as a competition becomes a game, and thus stimulates those engaged not only to strive with great energy but to derive keen pleasure from the contest. The business man who continues to pile up millions, long after his wealth is sufficient to satisfy every possible want,

does so from pure joy in the contest to excel others engaged in the same business. He is following the law of competitive work.

By pitting one gang of workmen against another gang, the spirit of contest is easily aroused. But it is impossible to maintain this spirit indefinitely without following the seventh law of management of men—namely, by making the reward proportionate to the performance. When, however, this seventh law of management is observed, an added spirit is given to men by pitting one gang against another. Thus, in laying concrete by hand for a pavement, the best method is to have two distinct gangs working side by side, each gang concreting from the center of the street to the curb. When this is done under a bonus system of payment, the output is astonishing.

Where competing workmen cannot see one another's output, a bulletin board should be used, whereon the number of units of work performed by each man or each gang of men should be posted.

Convert work into a competitive game by organizing competing gangs of men and by posting their performance.

The Law of Managerial Dignity.—That there should be anything like caste among managers seems, at first, repulsive to democratic principles of government, whether the government be political or industrial. Nevertheless, a study of the personality of the most successful managers usually discloses a characteristic of firmness coupled with a sort of austere dignity. The best manager is never "one of the boys."

Managerial control reaches its acme of excellence in the army, and there we find class distinctions most scrupulously observed. The officers do not "mess" with the men, nor do they form close friendships with the soldiers in the ranks.

Familiarity breeds contempt, or it breeds at least a feeling that the great man is not so great after all. All managers are under the constant fire of criticism of their subordinates, whether they realize it or not. The best shield that a manager can wear is distance. His little foibles—and all men have them—may thus be kept concealed. It is essential that they be concealed, for men of less mental endowment will always seize upon the little defects of greater men's character or attainment as evidence of lack of any real superiority. The eye of criticism is a microscope for human frailties. Being a microscope, it is wise to keep

beyond its range, so that the whole character may be viewed by the naked eye in its true perspective.

Discipline in an industrial army is as essential as in a military organization, and it is best secured by military methods. This involves: (1) The social separation of the officers from the men; and (2) a sequence of responsibility from the man in the ranks to the highest officer.

For every act on the work every man should be responsible to some particular man higher in authority. There should never be any doubt as to whom a man is responsible; but it does not follow that a man should be responsible to only one person, except for certain acts. As we have previously shown, an industrial organization may have several *classes* of foremen, to each of whom each workman is responsible for certain acts. What we now emphasize is the importance of not dividing the responsibility for any particular act. A contractor, for example, should rarely give any orders to a workman. All orders should come through the proper foreman. To do otherwise results not only in reducing the workman's respect for the foreman, but it frequently angers the foreman, who feels that he has lost dignity in the eyes of the workmen.

It is often wise to change foremen from one gang to another, in order to preserve the class distinction between foremen and men. As foremen become acquainted with the men, they generally want to be regarded as good fellows, and will then permit infractions of rules and a general decrease in activity. Who has not noticed that short jobs usually move with a "snap" that is not always characteristic of longer jobs?

We may sum up thus:

Discipline is best secured by managerial dignity, and dignity is best preserved by social separation of managers from subordinates and by an invariable sequence of responsibility.

The Law of Separation of Planning From Performance.—As a corollary to the law of the subdivision of duties, we have the law of divorce of planning from performance, first formulated by Mr. Taylor.

According to the old style method of management, each foreman is left largely to his own resources in planning methods, in addition to his other functions. This multiplicity of duties can be properly performed only by a foreman possessed of a multiplicity of talents. Since few men can comply with such a

specification for brains, it follows that good foremen of the old style are rare indeed. The modern system of management consists, as far as possible, in taking away from the foremen the function of planning the work, and in providing a department to do the planning. Under planning we include inventing, that is, the improvement of existing methods and machines.

A common error in management is the assumption that the man on the job in direct charge of the work is the man best fitted to plan and improve. Nothing is further from the truth. Rare, indeed, is the man possessed of a trained inventive faculty, and it requires such a faculty not only to develop new methods and machines but to plan the use of any machine with greatest economy. Nearly every piece of contract work presents new conditions, and this solving of new economic problems is beyond the power of any but the trained and skilled economist. But even where the problems remain identical, the necessity of a divorce of planning from performance exsits, as we shall indicate.

The brain is an organ that requires frequent exercise in doing the same thing before it becomes proficient enough not to suffer great fatigue. Thus, the man who is learning to ride a bicycle finds that half an hour's lesson has tired him more than 10 hr. work at his accustomed occupation. Attempting to do something new is wearisome beyond measure, except to the mind whose training has been in solving new problems. Hence the ordinary man finds much fatigue and little pleasure in attempting to do his work in a fashion that differs at all from that to which he has long been accustomed. The mental inertia that resists a change in methods of performing work is almost beyond comprehension, and it is found not only in the lowest type of workman but in the highest.

Repetition develops skill, and skill gives pleasure. To a strong man used to his work there is actual pleasure in mowing hay, as Tolstoi has admirably pictured in one of his novels. Conversely, fatigue merges into pain and is repulsive.

In addition to these fundamental reasons why men adhere to precedent in their proformance, there is the fear of ridicule in case of failure to succeed in any new attempt. The child learns to speak a foreign language more rapidly than an adult not only because of a more "flexible tongue" but because it does not fear laughter at its blunders. Partial failure is expected of the child,

and it is not ridiculed. But an adult seems witless if he does not immediately learn the new word and its pronunciation; hence the laughter. So it is with every new performance. Furthermore, a serious mistake may lead to the loss of a position, thus adding another reason for sticking to the "good old way."

Finally, there is no method so fruitful in effecting improvements in methods and machines as a study of the time required to perform each movement of operation. A workman or foreman rarely studies his own work in this manner. Hence his experience, upon which he is wont to brag, is like the experience of the swallow building its nest—an unchanging adherence to precedent, regardless of possibilities of improvement.

It is a significant fact that nearly all the great inventions have been the product of brains divorced from the actual performance of the machines that they have invented. Eli Whitney, inventor of the cotton gin, was a lawyer, and not even a southern planter. Smiles' "Self Help" is a volume full of instances of important inventions made by men remotely, if at all, connected with the class of industry in which their machines are used. Nothing, therefore, is more ridiculously illogical than the common belief that the "men behind the gun" are either capable of being the inventors of the gun or the ones likely to improve it. Yet it is this illogical belief that prevents railway companies, manufacturers and contractors from making hundreds of radical economic improvements.

There is another difficulty, one which is most insidious and not generally recognized among contractors. It depends upon a mental peculiarity, to which we know of not a single exception, which becomes increasingly evident as a man's familiarity with the work develops. The fact referred to is this: A field chief can see inefficiencies in operation and prescribe remedies far more unerringly when his personal active touch with any one piece of work is intermittent than when one job is his constant care. The ultimate reason for this fact belongs to the science of psychology rather than engineering, and its theoretical investigation is not our present concern, but the fact is there and it has got to be respected. Coming back to a job after two or three days spent on another kind of work, with another kind of responsibility and among another set of men, things are seen that were not before suspected, and the prejudices of practice, as they may be called, are offset by the distraction of other fields, without the

analytical perception having had the opportunity to grow rusty from disuse.

Still another fact, equally important, equally elusvie, equally difficult to demonstrate to the theorist who has not had field experience and to the old-timer who is hide-bound by precedent, is this: A man, no matter who he is, can do his work better, vastly more efficiently, when he is being coached than when he is his own guide, philosopher and friend. Why this is true we will not here take the time and the space to discuss. It is true at a rifle range, on the baseball diamond, on the football field, in rowing, in track athletics, in the machine shop, and in field construction work. A man can steal third base better under coaching, even with the handicap of the impressions having to go through the mind of the coach before he can make use of them, a matter involving a considerable interval of time. The coach must know his business, of course, and have the confidence of the worker; and in its field application the cost of the coaching must not be excessive, nor need it be. A coach can act in that capacity to a good many men at once, and, if he be allowed to confine himself to just one function for a considerable tine, he can obtain a control of other men on this function that is astonishing. This is the basis of the employment of functional foremen first developed by Taylor.

We might multiply instances indefinitely, but it is clear from the above that the economic systemizing of any specific piece of work of any considerable size must be done by a thoroughly disciplined and well trained staff under the leadership and direction of the best man available; and it is further evident that if the services of the field chief on any one job can be made intermittent, visits being at reasonably short intervals, his efficiency will be a maximum. The superintendent in charge of the work has a continuous responsibility and a continual care. His coach, his friend and his chief must have a broader and less confining field.

Not being on the job continuously, the chief will obtain unfair impressions unless fortified by an efficient and well ordered cost keeping system.

In agreement with the three preceding paragraphs, it has been found that the reorganizing of work is done much more efficiently by men who have not been a part of the permanent organization, than when attempted by an old employee on the work. This statement applies to large organizations as well as small, and has

been proven true on the railroad, in the shop and in the construction field time and time again; and the fact frequently offers a particularly unfortunate obstacle to the employment of the best men for the work, because many men in construction business dislike to entrust their trade secrets to an outsider. As a matter of fact, the trade secrets on construction work that are worth concealing, if shaken up in an ordinary peanut shell, would make a distinct rattle; but a contractor seldom likes to have his precise costs known outside of his own organization, lest someone else might have an advantage in bidding against him. He has confidence that the men in his own employ will not give away his figures to his business rivals and he has not the same confidence with regard to a rank outsider. In practice, however, it works out differently. The employee who has gained such knowledge of the business as to make his information valuable can, and often does, better his job by going over to another contractor. The outside expert is under the strictest obligation of professional honor not to betray to one client the secrets of another, and we have yet to learn of such a thing being done by men with a reputation to sustain. A contractor's "costs" are safer in the hands of his consulting engineer than in his own office.

Summing up, we have this law:

For maximum economy of performance, the planning of methods of doing work should be the sole function of a manager who is not a workman himself nor in direct charge of the workmen.

The Law of Regular Unit Cost Reports.—Having planned a method of performance, it becomes necessary to secure daily, weekly and monthly reports of such completeness that a manager can tell, almost at a glance, what the actual and relative performances are. This systematic reporting is more fully treated under the head of cost keeping. The success of nearly all large corporations, such as the Standard Oil Company, is due, in large measure, to a system of regular reports that put the various managers in constant touch with the performance of the men under them. Reports to be of much value must come at short, regular intervals, must be in the same form, and must show quantitative results that admit of instant comparison with previous reports. To permit comparison there must be either similarity of conditions, or there must be a reduction to units that are themselves practically identical. For example, a weekly record of the number of yards of earth excavated and hauled at

a given unit cost is usually of little or no value to the manager unless there is a further subdivision of units of cost. The cost of loading per cubic yard should be segregated from the cost of hauling, so that the cost of hauling can itself be expressed in the unit of the yard-mile or ton-mile hauled.

The law of regular unit cost reports may be formulated as follows: *Report all costs in terms of units of such character that comparison becomes possible even under changing conditions, and let these reports be made daily if possible, weekly in any event, and with a monthly summary.*

It is in the adherence to the terms of this law that managers of contract work in the field will find their greatest difficulty. First, there is the difficulty of selecting suitable units upon which to report costs. In pavement work, the square yard is a convenient unit and the number of units is easily measured daily. But in reinforced concrete building construction, there is needed not merely the cubic foot or cubic yard unit, but many others, some of which are not easily ascertained every day.

For example, the pound of steel reinforcement is one unit upon which reports should be made, for the number of pounds of steel per cubic yard of concrete differs widely. The thousand feet board measure in the forms is another necessary unit, and the square foot of concrete area covered by the forms is still another. Yet these and other units must be used to admit of any rational comparison of performance from day to day and week to week.

In the evolution of scientific cost analysis five kinds of units were successively developed:

1. Time units.
2. Sale units.
3. Dimension units.
4. Work units.
5. Formula units.

The *time unit* of cost is the cost per unit of time, as the day, week, month, or year. All interest costs and most depreciation costs are time costs. Many other "fixed costs," such as rent, supervision, etc., are time costs; that is, they are a function of time rather than of output. Hence time units will always remain useful as measures of certain costs of production.

Where the number of production units is practically a constant —as the weekly car-miles of a street railway system—the time

unit of operating cost may be of great value in contrasting one week's, month's or year's cost with another. But it is not commonly the case that the number of units of product is the constant per unit of time. Indeed, wide fluctuations in production frequently occur. Therefore it early became the practice to express costs in terms of sale units.

A *sale unit* is the unit of product in which selling prices are expressed; as, the ton of pig iron, the cubic yard of concrete, the kilowatt hour of electricity, etc.

While the sale unit of cost is still more commonly used than any other, with the possible exception of the time unit, and while the sale unit possesses merit, it is a very imperfect criterion for judging the cost of many products. Thus, the cost of excavation expressed only in the sale unit of the cubic yard means next to nothing unless accompanied by a statement of many local conditions. The length of haul may, and often does, become a far more important cost element in earthwork than all other items combined. Then the sale unit (the cubic yard) ceases to have much significance as a cost unit when taken merely by itself.

The sale unit of freight transportation was originally the ton-mile. Here, too, we have an imperfect unit in which to measure all transportation costs. Railway track maintenance cost is less a function of the ton-mile than of the car-mile, and most of such maintenance is not a function of either. Ties, for example, decay as fast in an unused track as in a used track. Perception of such facts led to the adoption fo two kinds of cost units that are quite independent of sale units; (1) dimension units, and (2) work units.

A *dimension unit* is a unit of length, area or volume. Thus, the mile of track may be used as a length unit in which to express the cost of track maintenance. Thus, the square yard of concrete surface may be used as an area unit in which to express the cost of forms or molds. Thus, the cubic foot of building content may be used as a volume unit of building cost.

Obviously a volume unit is convertible to a weight unit if the specific gravity and voids of the material are known. Hence we shall include weight units when we speak of volume units in this discussion.

In selecting dimension units that are better criteria of costs than sale units, the instinctive aim is to choose a dimension unit that shall directly measure the approximate amount of labor required to produce the unit. The next step in the evolution

of cost units was to do with more scientific precision, that, that had been done by instinct. That is, to select for cost units those that were more truly measures of the labor required in their production. These we shall call work units.

A *work unit* is a unit that directly measures the approximate cost of labor involved in its production.

If all work were done without tools, or with tools of perfect efficiency and costless in themselves, then the ideal work unit would be the foot-pound or some multiple thereof. In other words the work unit would be the product of some weight (or force) and the distance through which the weight (or force) moves. Even though this ideal work unit is rarely a perfect measure of labor costs, it is always well to have in mind the ideal when selecting a work unit for practical use. Thus, in selecting a work unit for hauling or transportation costs, one should be chosen that will be approximately a function of distance multiplied by tractive resistance. The car-mile fulfills this condition better than the train-mile, for example.

We have come now to the latest development in unit cost analysis, namely the formula unit, as we shall designate it.

A *formula unit* is a composite cost unit made up of simple cost units, each of wh ch measures approximately or exactly the cost of a certain part of the total.

Nearly every satisfactory formula unit is a composite of the three classes of units that we have discussed, namely: (1) Time units, (2) dimension units, and (3) work units. A formula unit may be itself a sale unit, or it may be some arbitrary unit that merely serves to sum up all the sub-units of a given kind, or of a multiplicity of kinds. It may be the cubic yard of masonry, or it may be x—an arbitrary unit. In all cases, however, the formula unit is one susceptible of expression as the left-hand x of an equation in which the right-hand member contains all the sub-units that respectively measure the corresponding costs with approximate correctness.

Thus,

$$x = a + b + c$$

Here x is the formula unit cost which for example, may be the cost of a cubic yard of excavation. Then a may be expressed in terms of a time unit, and may include certain fixed costs; b may be expressed in terms of a dimension unit, such as yard; c may

be expressed in terms of a work unit, such as the ton-mile of haul.

No matter what cost unit is adopted, periodic comparison of unit costs in totals and in sub-totals is one of the most fruitful means of discovering wastes and of awakening the managerial mind to the possibilities of reducing costs by change of men, change of methods, change of machines, etc. To do this, unit costs for each period should be divided into sub-units, and either tabulated or plotted diagrammatically, or both. The diagram is usually more striking in its presentation of cost variations than is the table, but the diagram may be too bulky for convenient use, and otherwise objectionable.

To make a table more effective for comparative purposes, it is a common expedient to express sub-unit costs as percentages of the total unit cost. This is often very illuminating. Not only does a percentage show the relative importance of a sub-unit cost but a change in percentages at different periods is readily noted.

The cost of certain sub-units is often a function of the cost of other sub-units or of the total unit cost, or of the total income, so that comparisons of percentages, as above outlined, become very instructive. Frequently, however, the functional relation is such that when one sub-unit cost goes up another sub-unit cost goes down. Thus, a moderate increase the cost of management usually results in a decrease in the cost of the direct labor. So, too an increase in plant costs is usully accompanied by a decrease in direct labor costs. The manager who is fully informed as to scientific methods, will study the quantitative relation between sub-unit costs that vary inversely, one to the other. If the quantitative relationship can be established, it can be expressed in the equation that gives the "formula unit" cost. Then it becomes possible to apply the science of mathematics to this unit cost equation and solve for a minimum unit cost. Toward this goal all scientific cost analysis trends.

The managerial law of unit cost reports may be re-expressed thus:

To secure economic production, all costs should be periodically reported in terms of sub-units, each of which is a function of the labor performed and materials used in its production, and these sub-units should be summed up as to give formula unit of total cost.

In order to secure the greatest results from such reporting of unit costs, experiments should be made to establish the functional

relation of the sub-unit costs to one another. If such relations can be expressed quantitatively, it becomes a simple matter to solve for a minimum total unit cost, insofar as such a minimum can be secured by relative changes in the costs of the sub-units themselves. While this method is usually exceedingly fruitful as a means of reducing the total unit cost, the mere recording of formula unit costs is itself both a stimulus to cost reduction and to the exercise of ingenuity to better the past records.

"Chance" will often cause variations in unit costs, and the natural effort to account for any variation in the records may lead to most important discoveries. Without records of unit costs "chance" results would ordinarily escape unnoticed.

Unit cost records can be used to show the relative efficiency of all men and particularly of those who direct the work of subordinates. Competent foremen and superintendents are thus "discovered" much more certainly and expeditiously than is possible in the absence of unit cost records. Incompetence is likewise disclosed before serious losses occur.

Although it is generally conceded that unit cost reports lead to economics, it is a rather remarkable fact that relatively little effort is usually expended by managers in perfecting cost keeping systems and in deducing formula unit costs. If it is difficult to measure the number of units of output of an individual or of a gang, the difficulty is often made the excuse for not attempting to surmount it. So prone are managers to avoid such difficulties that there is scarcely a field of human effort to-day where greater harvests await the reaper with brains than to be found in this very field of unit cost reporting. The average manager is content with securing cost records of a very general character, and usually expressed in units that are not formula units, in other words in units that are such as to mean next to nothing except to the man who made the cost records himself, and that usually mean little enough to him.

The general failure to secure records of work done in terms of units that truly measure the work is largely accountable for the failure to pay men in proportion to their output, and this, in turn, is the secret of much of the inefficiency that managers blame upon their employes, when, in truth, the blame should rest upon the blamers.

The Law of Systemic Research.—Although it is evident that the object of all management should be to increase profits, both

by increasing sales and by reducing unit costs, it has not been the general practice to investigate existing methods and machines systematically with a view to reducing unit costs. The Taylor scheme of timing the elements of operation of machines has merited all the praise that it has received. But it seems not to have been perceived by many of the exponents of "scientific management" that unit timing of processes is itself only one method, and not the most important method, of conducting systematic research for the purpose of devising more economic methods of production. Nor has it been generally recognized that unit cost keeping—which is a much older device—is also but a method of conducting a continuous research whose ultimate aim is the reduction of unit costs.

Systematic research, then, is a broad principle to be applied in all management, and, as we shall indicate, it may receive application in numerous ways.

The greater part of Wellington's "Economic Theory of Railway Location" is devoted to investigation and analysis of the costs of railway operation—a systematic research. Using the data thus collected, Wellington proceeds to solve for a minimum unit cost of transportation under any given condition. His whole treatise is, in fact, an application of two principles of the science of management.

Another sort of systematic research has been applied with remarkable results by certain manufacturers and by a few railway companies. We refer to laboratory experiments with materials and devices. Research laboratories are characteristic of many large electrical and chemical manufacturing establishments. Recently several technical articles have been published giving exact data as to some of the economies effected by investigators in these laboratories. That such laboratories have long been maintained at great expense is itself sufficient evidence that this sort of systematic research pays.

If we turn to the various departments of the federal government we shall find more or less evidence of systematic reserch undertaken to effect economy of production, but in no department does it approach in its results what has been accomplished by the Department of Agriculture. Within the last few years the whole art of farming has rapidly been elevated to the rank of a science, and this change has been due in large measure to the systematic research conducted by the Department of Agriculture. Profiting by this example, several railway companies have undertaken

similar scientific investigation for the purpose of teaching the farmers in their territory how to produce larger and more profitable crops.

The manufacturers of machines have usually been content to effect improvements slowly, either by adopting the suggestions of owners of the machines or by using the invention of some employe or of some free lance in the inventing field. Latterly, however, many of the most progressive manufacturers are hiring engineers to make a systematic study of the work performed by the machines under all kinds of conditions. Two results are accomplished by this sort of research: First, the machine itself is improved; and, second, methods of using the machine are bettered, and owners are taught how to use the machines to greatest advantage.

Like many another principle whose merit is conceded, the principle of systematic research does not as yet receive a fraction of the attention that it deserves. The majority of business firms are small, and the manager of a small firm is apt to say: "Systematic research is all very well for the big business concern but we, being small, have neither the money nor the time to devote to such things. It keeps us busy enough doing what we have to do now."

In this argument we have one of the main reasons why most small concerns remain small. Unless the manager of a small business takes the time himself or assigns someone else to study the problems of economic production and selling, he will always be extremely busy—busy trying to keep from going to the wall under the stress of competition. Systematic and continuous research is the secret of the rise of many a small firm into prominence. Such research usually begins with unit cost keeping and a careful study of the elements of cost with a view to cost reduction. Then it may be followed by the Taylor method of unit timing of operations. Then laboratory and field research may follow, leading to a number of small improvements, which, in the aggregate however, add very substantially to the economy effected. Finally some radical improvement, so radical as to merit being called an important invention, gives the business a great forward impetus. The invention need not necessarily consist in a mechanical combination or in a chemical combination, for it may be a greatly improved process or product that is not even patentable.

Failure to succeed greatly in management usually occurs not so much from lack of knowledge of the important principles of the science of management as from failure to apply them. Most of the principles of successful management are old, and many of them have received sufficient publicity to be well known, but managers are curiously prone to look upon managerial success as a personal attribute that is slightly dependent on principles or laws. In fact, however, managerial success is but an evidence of skill in applying the laws of management. The laws, it is true, may not have been learned from books. More often they have been derived from experience and intuition, which is but a way of saying that they have been arrived at by a process of induction. None the less, every successful manager owes his success to an understanding of at least a few of the important laws of the science of management, which laws he has diligently and skillfully applied. This statement carries with it another: "Scientific management" is new only in name. Every successful manager, from immemorial time to the present, has applied laws of management that are scientific. It is true that there has been no codification of the laws of scientific management into a science until recently. It is also true that no scheme of management that involves the application of only three or four of the laws of management is a *science* of management, although such a scheme may be *scientific* management. An act may be scientific but an act can never be a science.

The recent attempt to accredit a certain system of "scientific management" with the attributes of a complete science of management has aroused much just criticism; but the critics have themselves usually gone to an equal extreme in maintaining that there is no such thing as a science of management. Some, indeed, have claimed that such a science can never exist. Prior to Aristotle it might have been argued with equal seriousness that a science of reasoning—logic—could not be developed, for it could have been said: "A man is born either with or without a faculty for reasoning well, and cannot be taught to reason." There is now a science of reasoning, and the science of management is itself one of the developments of inductive logic.

Among the principles of the science of management, one of the most important may be stated thus:

To secure greatest economy of production, regular systematic

search should be employed, with a veiw of improving materials, machines and methods.

Systematic research involves: (1) Unit cost keeping and cost analysis; (2) unit timing of operations; (3) laboratory testing and experimenting; (4) systematic investigation and experimenting in shop and field under working conditions.

In conducting such research there is a great field for trained engineers, and particularly for those who have an imagination that leads to the invention of improved means and methods. Few, we believe, are wholly lacking in such imagination, and in all it can be developed to a greater degree by study and application of the principles of the science of management.

A Principle of Management: "Credit to Whom Credit is Due."—So long as selfishness is characteristic of men it will be difficult to prevent department chiefs from claiming credit for improvements effected by their subordinates. Nor does the difficulty end there. Even the highest officials are given to claiming, or, if not claiming, accepting credit for things accomplished by their superintendents and managers. This condition of affairs is so prevalent and so restrictive of economic progress that every possibility of its eradication by better managerial methods should be investigated.

Recently C. A. Whelan, president of the United Cigar Stores Co., addressed a communication to all the salesmen of the company telling them not to hesitate to go over the heads of their superior officers in making suggestions for improvements. He said:

"Recently an official of this company received an unsigned letter from one of our salesmen. The reason given for withholding the signature was, the writer said, that he 'was afraid if he were known it might cause hard feelings on the part of the sales manager.'

"I believe few of our men have this idea, but in case you are laboring under this impression I would like all of our men to know that they have the privilege of addressing by letter or communicating in person on any subject, with any one of our officials or heads of departments without fear of consequences due to the attitude of a sales manager or superior.

"I believe that our sales managers are broad enough not to take offense because of any difference of opinion between them and their men.

"Should there be occasional instances of this kind, however, I can

assure you that no harm will come to any of our salesmen because of the narrow view of a sales manager, or anyone else.

"Our officials and heads of departments are at all times glad to get criticisms and suggestions from our men on the 'firing line.'

"Let this be an invitation to you to give us your ideas freely and frankly.

"When you think you can improve the business or have criticisms which are either your own or have been made by your customers, come to us with them."

Unfortunately we can not agree with Mr. Whelan in his statement that a sales manager is not likely to take offense at attempts by salesmen to go over his head. The stubborn fact balks in the face of Mr. Whelan's optimism. Men are not so free from pride and selfishness as to make it probable that the average manager will be pleased with any act that looks to him like insubordination. If there is to be the harmony so essential where industrial "team play" is involved, some way must be devised to give credit where credit is due, without giving offense where offense should not be due.

As one looks over the periodic reports of superintendents, managers and presidents of organizations, it becomes noticeable how scant is the recognition given to those below them in rank. Investigation shows that this characteristic extends even below the written report to the word-of-mouth report. Has the gang boss utilized a good hint made by a workman? Then look to see the gang boss placidly accept all credit for it. Has the foreman of several gangs successfully applied a suggestion made by a boss? Look to see the foreman tell the manager about it without mention of the boss. And so on up the line, even to the president of a company reporting to its directors and stockholders.

There are, of course, some happy exceptions to this rule, for men are not all selfish, or, if selfish generally, are not so always.

As a first step toward proper recognition of each man's economic achievements it may be well to require periodic written reports from all managers, wherein are given brief statements of all suggestions for improvements together with the name of the originator of the suggestion. To make this plan most effective, not only should there be described the accepted suggestions but the rejected suggestions. To do the latter would be a decided innovation, but it would serve to bring to the attention of the

highest officials many ideas of real merit that would otherwise die at birth.

Reports of managers are seldom seen by their subordinates, and this accounts in part for the failure of such reports to give credit where credit is due. Hence it is desirable to bulletin or otherwise publish reports of the character above outlined. In the case of some companies, it might be wise to read the reports before the assembled staff of employes.

Managers can soon be made to see that they need not themselves be very original men in order to be very valuable managers. The fact is that originality and managerial ability are not often found in one individual. A manager to be capable need have little other ability than the ability either to find capable subordinates or to arouse their latent powers. Couple this capacity with good judgment and you have a good manager.

A few establishments encourage employes to send in written suggestions, and for acceptable suggestions they give small prizes. The plan is good as far as it goes. It can be made to go much farther by incorporating such suggestions in a periodic report, and by subsequently paying the suggestor adequately for his idea. A petty prize of a fixed amount is some stimulus, but a real reward proportionate to the worth of a new idea would excite vastly greater activity of the wits of employes.

Most large industrial companies require their salaried employes in certain departments to sign a contract under which the employe is constrained to assign to the company any invention that he may conceive while on the company's payroll. Could any scheme be devised that would more effectually stifle an inventive man's inventiveness? Not a word is said in such a contract about any commensurate reward for an invention. Here again appears the same old selfishness and desire to seize all the credit save the mere paper crown that the patent office may place upon the inventor's head.

Can we not all work more strenuously toward the goal of "credit to whom credit is due?" And in doing so, can we not do our share toward bringing about a "credit" substantially expressed in dollars?

CHAPTER II

RULES FOR SECURING MINIMUM COST

In our own work we have found it of great advantage to formulate certain rules for reducing costs; for a study of specific general principles leads to many improvments in management that would not occur if reliance were placed upon haphazard attempts to reduce costs. The following are some useful rules:

1. The sum of the items of unit cost must be a minimum.
2. Express all items of cost as percentages of the total, to ascertain the relative economic importance of each item and thus determine where it is best to make the first efforts at cost reduction.
3. Express the value of all lost time in percentages of the total cost of each part of the work, classifying the various items.
4. Keep down the ratio of overhead charges to direct charges by night shift work.
5. Since the principal factor of the unit cost of production where power machines are used is the labor of attending the machines, reduce the cost of this attendance even at the expense of a large increase in plant charges.
6. In selecting plant consider particularly the unit cost of moving and shifting it and the cost of lost time.
7. Work every element of a plant to its capacity.
8. Use every possible means to avoid accidents to plant by proper inspection and study of precautionary measures.
9. Consider the animal body, whether of a man or a horse, as a machine burning a limited amount of fuel daily, in the form of food, and therefore having a limited daily capacity for work.
10. Use low-priced men to do all work involving merely foot-pounds of energy.
11. Make the sum of the items of work, measured in foot-pounds, a minimum.
12. Do the most profitable part of the work first wherever possible, so as to avoid carrying interest charges.
13. Make all designs for work, whether permanent or temporary in the office as far as possible, instead of leaving this to the ingenuity of foremen or carpenters, to be done in the field.
14. Do as much as possible in a yard or shop instead of in the field.
15. Transport and handle pieces in groups, each group being the unit handled.

16. Resolve each class of construction into the elements of work involved and study means of reducing the foot-pounds of each element.

17. Ascertain the percentage of dead work done in conveying and elevating material, with a view to determining its relative importance and thus deciding upon what it is worth to reduce it.

18. Cultivate a strong *Esprit de Corps* by strengthening the personal relations between the management and the personnel and by keeping the "labor turnover" at a minimum.

Rule 1.—*The sum of the items of unit cost must be a minimum.* These items are:

(*a*) Plant and tool charges.
(*b*) Operating labor charges.
(*c*) Material.
(*d*) Preparatory and incidental charges.
(*e*) Cash capital.
(*f*) Overhead charges.

The plant and tool charges comprise:

1. Interest.
2. Depreciation.
3. Repairs.
4. Installing and removing, including freight.
5. Shifting during construction.
6. Supplies, such as fuel, oil, waste, etc.
7. Watchman.
8. Storage during idle periods.
9. Insurance.

The total plant charges for an average year must be calculated and divided by the total number of units of product for an average year, or for the fiscal period on the basis of which the work in question is to be considered. This result will give the unit plant charge.

The operating labor charges comprise the labor which is directly productive, such as that of a man handling a pick and shovel; it comprises the incidental labor, such as that of the water boy, etc.; the monthly labor, such as, that of the timekeeper and storekeeper; and the labor of superintendence. The sum of the amounts paid for this labor for the fiscal period under examination divided by the total number of units of product will be the total unit labor charge.

The total cost of material for a given result, or for a given

period divided by the total number of units of product, will be the total unit material charge.

The sum of all the charges for getting ready to do work which are not plant charges and which are incidental to the particular job handled, and yet not necessarily proportionate to the amount of work to be done, divided by the total units of product or profitable work upon the job for which these incidental charges are incurred, will be the total unit preparatory charge.

The interest upon the cash capital involved for a given peroid divided by the number of units of product or profitable work of each kind for a period under investigation will be the total unit capital charge.

The total charges which are not directly apportionable to any one job, and yet are essential to running the business, divided by the total number of units of product or profitable work handled by the entire organization for an average fiscal period, will be the total unit overhead charge.

The sum of these six unit charges should be a minimum in order to obtain the minimum cost. It naturally follows that it is not necessary for each of these items to be itself a minimum, since, if by an increase in the unit plant charge, the unit labor charge can be more than proportionately decreased, there is a resultant economy; and, similarly, if by increasing, even temporarily, the unit overhead charge, the efficiency of the general work can be sufficiently improved, the total economy will be increased.

It is very important to consider items 4 and 5 of plant charges, for it often happens that a plant that is too large and too expensive is employed on work which is not heavy enough to justify such a plant. The use of a 90-ton steam shovel, costing perhaps $125 per day to keep in operation and turning out 400 yd. of material per day, costing a great deal to install and afterwards to remove, instead of a 30-ton steam shovel which might under similar conditions do 300 yd. of material at a cost of $55 per day, seems rather ridiculous; yet this sort of thing very frequently is seen.

Importance of Daily Unit Costs.—Complete unit costs should be made up daily or at most weekly intervals for each class of units upon which there is a contract price. Unless this is done it frequently happens that the contractor who thinks he has been making a profit on a job awakens toward its close to find

that he has actually lost money on it. Now he may lose money on the job even if he does have complete unit costs before him every day, for it is very common to bid so low a price that no profit can possibly be made. But it is surprising what a difference there is in the energy of a desperate man as contractor with one who is well satisfied. When a contractor realizes that he is daily sinking deeper into the quicksands of bankruptcy, he will usually "camp on his job" night and day, and his wits will be steadily at work. Whereas if he thinks he is making a satisfactory profit, he is apt to take things easy, let well enough alone, go off on frequent pleasure excursions and the like.

Incidentally it may be remarked that one of the reasons why day labor so frequently exceeds the cost by contract lies in the psychological fact that the engineers and superintendents in charge of the work have no pecuniary stake in the cost of the work.

Rule 2.—*Express all items of cost as percentages of the total, to ascertain the relative economic importance of each item and thus determine where it is best to make the first efforts of cost reduction.* Following this rule will frequently disclose astonishingly high percentage costs of items that seemed normal. Thus, foremanship expenses are often 10 to 15% of the total cost, where they could be cut in two by using larger working forces, by not working in winter weather when there is much lost time, etc.

Rule 3.—*Express the value of all lost time in percentages of the total cost of each part of the work, classifying the various items.* Such a classification should show:

(*a*) Time lost waiting for supplies or materials.

(*b*) Time lost waiting for other parts of the plant.

(*c*) Time lost shifting the plant.

(*d*) Time lost by breakdowns (which may also be classified).

Lost time is the bottomless pit into which more money has been dumped by contractors than can be estimated. It is not an uncommon thing to lay twice as much yardage of concrete on a day entirely free from delays as is laid on the average day. In other words, it seems practicable to do twice as much work daily as actually is averaged. How is this ideal to be attained, or at least approximated? Only by system, and system involves keeping costs in such a manner as to locate definitely and immediately each period of lost time for each gang, and the reason why.

Does the crusher shut down for an hour for repairs? Then the time report for the quarry must show the time of stopping and the time of starting, and the reason for the shut-down. It should be the timekeeper's duty at the end of each week and of each month to summarize all the time losses in the quarry, so that the contractor or his superintendent can see at a glance the size of this loss. Perhaps no better way than this can be invented to demonstrate what extra parts should be kept on hand to minimize delays. Here it may be suggested that whenever a new machine is purchased, the manufacturer should be asked to recommend what and how many spare parts should be carried in stock by the purchaser.

Where the cost of lost time due to breakdowns is kept, it frequently becomes evident that it is economic not merely to have spare parts on hand, but to have entire spare machines. Take a pump, for example, that is delivering water to a concrete mixer and for sprinkling, etc. Upon the service of that one pump will depend the progress of the pavement. Yet to save an investment of $500 to $1,000 in a spare pump, many a road contractor loses several fold that sum each year. Such losses result from failure to keep records that show the cost of lost time.

Rule 4.—*Keep down the ratio of overhead charges to direct charges by night shift work.* A large and expensive organization which is occupied in running a small job is a great burden upon the unit efficiency of work. To remedy this the usual method employed by contractors is to try to carry as many contracts as they can. In lieu of this when it is not feasible to get many contracts the ones on hand should be pushed at their utmost speed consistent with economy of operation. Sometimes this will involve working night shifts. On most steam shovel work night shifting is from 10 to 20% more expensive than day work as far as the direct labor charges are concerned, but this expedient enables the whole work to proceed faster, and aside from keeping down the percentage of overhead items it reduces the interest and depreciation charges on plant. Where the overhead charges are large, or when much expensive plant is being utilized, it is generally advisable to work double shifts excepting in very severe weather. However, it is generally recognized that where the plant investment is small and the wage item is high, it rarely pays to work at night, save for the purpose of completing a job within a time limit.

Efficiency of Night Work Dependent on Illumination.—It is generally agreed that night work is not as economic as day work where the work is done out of doors; but a thorough investigation of the reasons for the difference seems never to have been made. Consequently most contractors fight shy of night work, relying entirely upon the supposed truth of the generalization that it never pays except where work must be rushed to a finish.

Our experience leads us to believe that there need be very little difference between the output of the "owl shift" and the "eagle shift," provided two or three matters are given proper attention. The first of these is the matter of lighting. The second is the matter of warmth and food. The third is the matter of supervision and cost keeping.

Poor lighting not only retards progress because men can not work effectively in a twilight, but because it depresses the spirits of the workers. The mere fact that it is night has in itself no ill effect on the output of workmen: the night shift in a mine is quite as efficient as the day shift.

Night work above ground is often cold work in the spring and autumn. It therefore pays to see that the men are well clothed and that bonfires or other means of warming up are provided. Also frequent feeding of the men and still more frequent passing of hot coffee among them has a surprising effect. But above all in importance is the lighting of the job. Here is where a penny saved is apt to be a dollar lost. In these days of cheap illumination there is no excuse for not flooding the work with light.

The *Excavating Engineer* states that the Illinois Kaolin Co. operates a Bucyrus revolving shovel day and night digging clay and that after a month's experience the night output has nearly equalled the day output. The illumination is furnished by 11 General Electric 500-cp. flood lights. Nine of these are on poles 10 to 20 ft. high and can be adjusted to throw their rays in any desired direction. They give a strong light for about 2,000 ft. from the lamp. Two of the lights are non-focusing, for close range, and are suspended from cords so that they may be readily shifted, and thus give perfect lighting for the shovel work.

In this connection it is well to point out that the best type of electric light is the gas-filled tungsten lamp, for it consumes little more than half as much electricity per candlepower as the older vacuum tungsten lamp. Yet even the ordinary tungsten lamp is a cheap source of light. Thus a 500-cp. tungsten requires

about 0.6 kw.-hr. of current per hour, or 6 kw.-hr. per 10-hr. shift.

The following data are taken from *Engineering and Contracting* Nov. 15, 1916:

W. Michel, chief engineer of the Chesapeake & Ohio Northern Ry., stated that in filling trestles with gumbo, hauled several miles in trains, the night gangs on the shovel and trains averaged about 75% as great a yardage as the day gangs.

H. B. Whitney, a contractor of Emmetsburg, Iowa, states that on drainage work (using a 1-yd. dredge), where kerosene lamps and torches were used, night work was about 80% as efficient as day work. In habor dredging, where there was less wind at night, the night gang usually dredged slightly more than the day gang.

In hauling materials with motor trucks, many contractors find it profitable to work the trucks at night under certain conditions, particularly where the haul is long. Except over bad roads, a motor truck can safely travel almost as fast at night as during the day time.

Rule 5.—*Reduce the cost of attending machines even at the expense of a large increase in plant charges.* This may be done:

(*a*) By using as much power as one man can direct, without unduly increasing the weight of plant to be shifted. Thus, a 6-horse team driven by one man, so commonly seen in the West, greatly reduced the cost of operating the common transporting machine, the wagon. If each horse can pull one ton, in addition to the weight of the wagon, we have:

	Per day	Per cent
2 horses at $2.00	$ 4.00	57.1
1 man at $3.00	3.00	42.9
Total, 20 ton miles at 35 cts	$7.00	100.0
6 horses at $2.00	$12.00	80.0
1 man at $3.00	3.00	20.0
Total, 60 ton miles at 25 cts	$15.00	100.0

(*b*) By having one man attend two or more machines, as when one driver attends several one-horse carts in a quarry or on excavation.

(*c*) By using gasoline instead of steam, so as to dispense with a fireman.

(*d*) By using a central power generating plant, conveying the steam, air or electricity to the operating units.

(*e*) By using belt conveyors for short hauls.

(*f*) By using moving water to transport earth, sand or gravel in pipes or flumes.

(*g*) By concentrating the work where power can be applied at a few points. This is well exemplified in the use of a contractor's double track railway operated both ways by gravity with an incline at one end having a power driven endless chain for raising the single cars. In this way the cars travel both ways by gravity without attendants. Gravity is especially adapted to short hauls on contract work, where, either by building a light trestle or by digging a trench on an incline, the necessary grade can be secured cheaply.

(*h*) By use of power in the driving parts of a plant ordinarily driven by hand—*e.g.*, bull-wheel on a derrick—thus enabling the engineman to do not only the hoisting but the swinging of the boom.

(*i*) Often by the purchase of electric power and use of motors, thus avoiding the cost of handling fuel, and paying firemen, to say nothing of the cost of shifting boilers.

(*j*) By specializing the work of attendance, such as the delivery of material and supplies, which ought to be done as a special department by itself. When a drill runner has to run to the blacksmith shop for sharp bits or oil, the cost of attendance upon the plant becomes unnecessarily high. By having someone whose business it is to see that the high priced men spend little time waiting upon themselves, the economy can be much improved.

Rule 6.—*In selecting plant consider particularly the unit cost of moving and shifting it and the cost of lost time.* Contracting is really manufacturing with a plant that is moved either continuously or intermittently. Too much emphasis cannot be laid upon the necessity of studying the costs of moving the plant by ordinary methods, and the devising of less expensive methods.

The unit cost of transporting by means of a cableway is usually greater than by a railway, but the unit cost of installing and shifting the cableway is often much less. Bear in mind that a plant of large capacity often is least economic, because of the large unit cost of installing and shifting it. The unit cost of plant erecting and shifting may be reduced in many ways:

(*a*) By mounting it on a traveler, as when several rock drills are mounted on a traveler on wheels. This is often done in tunnel work, and could be frequently adopted to advantage on open cut work.

(*b*) By the use of light derricks or gin poles for erecting heavier derricks.

(*c*) By using guy-derricks instead of stiff-leg derricks.

(*d*) By using "locomotive cranes."

(*e*) By a light one-rail track fastened to the side of a steam shovel, and provided with a trolley for carrying the sections of steam shovel track from rear to front.

It is rare that any contractor is able to state what the "preparatory costs" have been on any given job, and this holds true even where the contractor has a cost keeping system. No argument is needed to prove that unless the "preparatory costs" are known there is grave danger of underestimating the total unit costs.

Having so kept the daily records as to show the actual cost of moving and installing a crushing plant, for example, to this should be added the estimated cost of shifting it (where shifting will be necessary) and the cost of dismantling and shipping it home. Then this total should be divided by the total number of cubic yards of stone to be crushed on the given job, to get "the unit preparatory and shifting cost" of crushed stone.

This unit cost should be added each day to the "unit overhead cost" and the "unit direct cost" for that day. The resulting total will then be really significant as to what the pavement is actually costing.

Rule 7.—*Work every element of a plant to its capacity.* A contractor's plant is usually composed of a number of elements, or units—*e.g.*, steam roller, traction engine, rock crusher, rock drills, boilers, etc. The plant should be so designed and handled as to work each of these elements to its full capacity. This may be accomplished thus:

(*a*) By coordinating the elements so that each element working to capacity keeps every other element that depends upon it working up to its capacity.

(*b*) By providing extra machines to avoid delays due to breakdowns or to necessary stoppages. Thus, for every eight rock drills in service, provide one extra drill. Also, provide an extra wagon or two when loading by hand on short hauls.

(*c*) By providing extra parts of machines and means for rapidly replacing worn or broken parts. It is not the cost of repairs that is usually an expensive item per unit of product, but the lost time of the entire plant and the working force.

(*d*) By giving each machine as uniform a "load" as possible, no "peak loads." If a machine is designed to provide for intermittent periods of heavy work, there is a great waste of interest and depreciation on the investment in the excess power capacity during the periods of normal exertion. Moreover, the machine subject to "peak loads" is heavier than one not thus subject to periods of extreme work, and is consequently more costly to transport, install and shift, which is not important in manufacturing but is very important in contracting.

(*e*) By giving the operating tool of the machine a rotary motion, if possible, instead of a reciprocating motion. This is a corollary of (*d*), for a rotary tool is generally constantly at work. Thus, a rotary auger should be used in all fireclays and soft shales instead of the ordinary reciprocating or percussion drill, for the constant application of the power of the rotary cutting tool puts no pulsating or "peak loads" on the machine.

(*f*) By providing stock piles large enough to tide over irregularities in delivery of materials. This is of exceeding importance on contract work, but is usually given scant consideration.

(*g*) By having one or more men at the manufacturing plant, stone quarry, or sand pit, from which the important materials are being purchased. In no other way is it possible to get uniform delivery of materials by rail from points distant from the site of the contract work. Often it pays to have a man whose sole duty it is to get empty cars from the railways and to go to freight yards and see that loaded cars are not held at the yard.

(*h*) By having, if necessary, an extra man or two on hand, and idle a good part of the time, who can jump in and clear away any material or obstacle that is blocking the full operation of the plant. A particular instance of this occurred some time ago on some steam shovel rock work in which considerable drilling had to be done in front of the shovel. As soon as the shovel stopped working it was necessary to get drills going immediately in order that the shovels should be idle as short a time as possible; and it was found highly economical to have a drill crew handy so that they could at once be turned over to the work in front of the shovel. Their time was economized, of course, to some extent

by having them ordinarily work as near the shovel as possible and calling them by whistle signal as soon as a shovel was blocked.

(*i*) By not having in service plant which is ordinarily capable of much more work than it is likely to be called upon to do. The most efficient way to work a dynamo or a boiler or a steam shovel is to work it to its regular capacity, and when it is working at less than this it is not as economical of fuel, of capital charges, or of the wages of the men who handle it as when its work is properly balanced.

Rule 8.—*Use every possible means to avoid accidents to plant by proper inspection and study of precautionary measures.* It is possible to make out an insurance policy against suits brought by men who are accidentally injured upon the work, but it is not possible to obtain an insurance policy protecting the contractor from the economic disadvantages resulting from accidental interruptions to the smooth progress of the work. The fall of a derrick may injure a man and the contractor be relieved from legal responsibility by the insurance company, but nothing relieves him of the loss in the efficiency of his work incidental to getting a derrick repaired and set up again, to say nothing of the discouraging effect of an accident upon all the workmen.

One of the commonest causes of delay to such operations as those involved in steam shovel work is the derailment of cars. This can best be guarded against by keeping the tracks in good line and surface, and by seeing that the cars are regularly inspected so that defects in the coupling or running equipment are speedily detected and repaired.

Where steam drills are runnning, breaks in the pressure supply pipe are to be looked for, and in freezing weather general bursting of pipes must be carefully guarded against as one of the most expensive things on the job. The pipes should be protected by lagging, burying in trenches, manure troughs, etc., and in addition to this many of them must be regularly drained at night. Carelessness in this particular is so common on the part of the average men on the work that the best method known to us is to organize a regular pipe gang whose business it is to see that pipes are kept open, and who are responsible for delays of this kind.

The break down of a flue in a steam boiler can come overnight through careless firing on the part of the watchman. The discharge of the watchman is small compensation for the damage that occurs as a result of it.

Rule 9.—*Consider the animal body, whether of a man or a horse, as a machine burning a limited amount of fuel daily, in the form of food, and therefore having a limited daily capacity for work.* Thus, a horse walking at a speed of 220 ft. per minute, or 2½ miles per hour, can exert a steady pull of 10% of its own weight for 10 hr. For a horse weighing 1,200 lb. this means 15,840,000 ft.-lb. of work daily, in addition to the work of raising its own body every time it takes a step. A man weighing 150 lb. can exert a steady pull of 5% of his own weight, or 7½ lb. at 220 ft. per minute, which amounts to 990,000 ft.-lb. per day, in addition to the work of raising his own body every step, which amounts to another 1,000,000 ft-lb.

When this rule (nine) is observed, the contractor will:

(*a*) Feed the workmen, as well as the horses, with abundance of nourishing food. On the Panama Canal the Jamaica negroes were at first regarded as being almost worthless as workers. Later it was found that the trouble lay largely in the poor food to which they were accustomed, and proper feeding greatly increased their output.

(*b*) Either house the workmen near the work, or transport them to the work, thus saving every foot-pound of energy for useful work.

(*c*) Teach workmen to use the heavy leg muscles instead of the arm and back muscles in lifting, shoveling, etc.

(*d*) Do not let the workman carry loads, if avoidable, for half his available energy is then consumed in the lifting of his own body (¼ ft. each step) when walking. On timber work, men are often seen carrying heavy timber with "lug hooks" or on their shoulders, where they should be pushing the timber on a "dolley" (a roller with a small platform on it) over run-planks. Hod carrying up a ladder should give place to lifting the loaded hod by a handpower elevator, if the size of the work does not justify a power elevator.

(*e*) Remember that at $2.50 a day for labor, and 1,000,000 ft.-lb. of useful work performed, the cost is $2.50 per million foot-pounds. That is $2.00 a day for a horse plus $1.50 for the services of a driver and 16,000,000 ft.-lb. performed, the cost is 22 cts. per million foot-pounds or $\frac{1}{11}$ the cost of man work. Hence horse power should be substituted for man power wherever possible.

(*f*) Select heavy men where heavy work is required, as in feeding a stone crusher whose output depends largely upon the strength of the men feeding it, for muscular strength is usually a function of weight.

(*g*) Use only heavy draft horses or heavy mules. A 1,600-lb. horse will do 33% more work than a 1,200-lb horse, hence a team of 1,600-lb. horses will do 66% more work, yet with no increased expense for driving.

Rule 10.—*Use low-priced men to do all work involving merely foot-pounds of energy.* For example:

(*a*) Don't let carpenters at 70 cts. an hour carry lumber that a 30-ct. man can carry as well.

(*b*) Have laborers clear away earth, loose rock, etc., over each proposed drill hole, instead of permitting drillers to do so.

(*c*) Plan the layout of work in such a way that the high-priced men have not only to move the shortest possible distance in order to handle their tools and materials, but arrange the direction of this motion so that as far as possible it may be down grade. Thus, have the bricklayers' helpers so place bricks for the bricklayers that, when the bricklayer grabs the brick, instead of raising it to its position upon the wall, he moves it either horizontally or down grade. The amount of fatigue incidental to the moving of one brick weighing 4½ lb. is almost inappreciable, but, when a man is laying as many as 3,000 bricks a day, the difference between raising it 2 ft. and bringing it down 1 ft. is over 25,000 ft.-lb., which makes a big difference in the total fatigue of the bricklayer.

Rule 11.—*Make the sum of the items of work, measured in foot-pounds, a minimum.* This rule is axiomatic, but, in spite of its self-evidence, it is rarely applied to all parts of a job. Work equals resistance in pounds multiplied by distance moved in feet ($W = R \times D$). Obviously, then, one of the first applications of this rule is:

(*a*) Reduce the distance from a machine to the center of gravity of the materials in the adjacent stock piles to a minimum. Thus, the broken stone stock piles should be placed nearest the concrete mixer, the sand next, and the cement farthest. The reverse is usually done, although there are six times as many pounds of stone as of cement in a yard of concrete. Engineers have often made this sort of blunder when designing cableways for transporting materials from scows, so that the broken stone

was to be moved about twice as far as the sand, and the cement was moved the shortest distance of all.

(*b*) By motion study and second-hand timing eliminate unnecessary motion and shorten the distance of necessary motions —*e.g.*, low wagon boxes loaded by hand (2 ft. of height saved may add 10% to man's output).

(*c*) Reduce the resistance:

1. By using rollers and wheels for transporting—*e.g.*, "dolley" for transporting lumber instead of carrying it; (2) by using runways, roads and tracks; (3) by balancing the dead load of buckets and skips, so that journal friction is substituted for a dead lift against gravity.

Rule 12.—*Do the most profitable part of the work first wherever possible, so as to avoid carrying interest charges.* For illustration we will take an example based on an actual experience, names and figures being assumed:

Contractor Jones had a capital of $30,000 and obtained a contract for $250,000 worth of earth and rock work. His estimate of cost was as follows:

Earth, 140,000 yd. at 50 cts. (including 5 cts. profit)	$ 70,000.00
Rock, 120,000 yd. at 1.50 (including 15 cts. profit)	180,000.00
Total contract	$250,000.00
Estimated profit—	
140,000 yd. at 5 cts.	$ 7,000.00
120,000 yd. rock at 15 cts.	18,000.00
Total	$ 25,000.00

or 10% on the whole amount.

The contract was for "unclassified" work; there was no discrimination made between rock and earth, but because he had been very friendly with the engineers who made the oringinal survey Jones felt that he was safe in trusting to the figures. The contract simply provided that for doing 260,000 yd. for excavation Jones was to receive the total sum of $250,000 payable in monthly installments as the work progressed, 10% to be retained until the completion of the work. The plan of campaign, which is the subject of this discussion, was as follows:

The earth was to be done first, and would yield the following results:

140,000 yd. earth at 96.154 cts. contract price	$134,615.39
10% retained until completion	13,461.54
Balance to be paid as work progressed	$121,153.85
Actual cost (estimated) 140,000 at 45 cts.	63,000.00
Balance available for running expenses	$58,153.85

Then the rock was to be done, amounting to

120,000 yd. rock at 96.154 cts.	$115,384.62
10% until completion	11,538.46
Balance to be paid as work progressed	$103,846.16
Actual cost, estimated, 120,000 at $1.35	162,000.00
Deficit on the rock	$58,153.84
Balance available on the earth work	58,153.85
Total of amounts retained (Total Profit)	$25,000.00

The work thus would "carry itself" except for the first month, supplies could be paid for on 30 days, a plant costing $40,000 could be paid on 90 days, and the money borrowed to pay three-quarters of this amount. On completion of the work the plant could be sold for a fourth of what it cost, and thus it was figured that a cash capital of $30,000 would be ample. What happened was this: When the time came to start on the earth-work there was no drainage, and no one thought of using a centrifugal pump in the shovel pit. It was then decided to get into the rock work first, borrowing some more money if necessary and do at least one-third of the rock work before starting the earth, then to do them both together. It works out as follows:

50,000 yd. rock at 96.154 cts.	$48,076.93
10% retained	4,807.69
Balance available	$43,269.24
Actual cost (estimated) 50,000 at $1.35	$67,500.00
Deficit on which interest must be paid	$24,230.76

When he had about 19% of his contract finished he was saddled with a fixed charge of 6% on $24,230.76, or $1453.85 per year. With extensions the working time was 5 years, or 4 years on which he was paying the above interest, and moreover, once

having started the rock work, it would have been expensive to drop it, so it was continued, the deficit and interest charges growing. The engineer in charge happened to be strictly honest and honestly strict, and would not budge an inch from the specifications. The surface of some of the rock work had to be "sand-papered," no latitude was allowed in regard to making waste heaps. If blasting did not go beyond the clearance plane the corners had to be knocked off, while if the blasting did go beyond the clearance plane the extra amount was not paid for. Before Jones took hold of the contract he had interested some strong financial people with him, more money was raised, and the work went on, at a loss and a big one, pushed to save the financial reputation of all the parties and because it was cheaper to go on at a loss than to default on a bond.

Rule 13.—*Make all designs for work, whether permanent or temporary, in the office as far as possible, instead of leaving this to the ingenuity of foreman or carpenters, to be done in the field.* Carpenters and foremen almost invariably use factors of safety that are unnecessarily large for posts, and often are altogether too small for beams. Moreover, their fastenings and joints are usually disproportionately weak. Hence they produce temporary structures that are much too heavy in most of the parts, and often dangerously weak in others. The "old hand at the business," as such men always claim to be, is often pretty much of an old fool when it comes to designing structures to resist stresses. On the other hand, the young engineer is apt to use too large a factor of safety throughout for temporary structures, particularly those of wood. The large factors of safety for timber recommended in bridge books are intended in part to cover subsequent weakening by incipient rot. Bins, forms, platforms, etc., that are to be moved frequently, should be bolted together, instead of spiked. Timbers can often be so fastened together, and left in full lengths without framing, as to be marketable after being used as falsework.

Where many moves are to be made, steel is frequently cheaper than timber in the long run, for it is less injured and shows a higher salvage value, *e.g.*, steel sheet piling, steel centering, etc.

Scaffolding may be largely reduced in cost by supporting such scaffolding as is necessary from the partly finished structure. This is well illustrated in the American method of erecting apartment houses and office buildings.

Falsework may often be done away with entirely by the use of a traveler, *e.g.*, the method of erecting steel viaducts with a traveler.

Rule 14.—*Do as much work as possible in a yard or shop instead of in the field.* Where economic means of transportation exist, and particularly where the work is of any considerable magnitude, but spread over a large area, it is usually desirable to do as much of the manufacturing of a structure in a shop or yard as possible. In this manner the plant loses no time from being shifted, and, since the expense of shifting is eliminated, a heavier plant with a larger daily output can be operated.

In building small reinforced-concrete culverts, we have found it most economic to make the floor, side walls and cover in a yard instead of on the site where the culvert is to be erected.

Timber structures can usually be framed at a very low cost in a small yard equipped with power saws, augers, and plant for handling timbers. Hence where there is much falsework to erect, either install such a plant, or have the framing done at a mill.

A cheap roof of boards covered with tar paper can be placed over a small yard and thus enable the work of framing, riveting, stone cutting, concrete slab making, etc., to go on without interruptions from the weather. Considering the slight cost of such roofs, it is surprising how seldom contractors build them.

Rule 15.—*Transport and handle pieces in groups, each group being the unit handled.* This is, perhaps, one of the most important rules for economic construction, and is susceptible of wide application. The following are some examples:

(*a*) Brick handled in packets as described in Gilbreth's "Brick Laying System." This method of handling bricks is to load 16 or 17 bricks upon a little wooden frame made of four pieces of wood nailed together and of such shape that they can be carried by the workmen as a convenient load. These 17 bricks will weigh about 76 lb. and make a packet which is of convenient weight for one man to handle economically where the carry is comparatively short. Mr. Gilbreth's method is to load the bricks upon the packets in the car on which they are delivered to the work, or even in the loading yard, and to handle them in units in this manner until they are deposited about 21 in. from the wall alongside of the brick layer in such a position that he

reaches for every brick with his left hand in the same manner and in the same relative position, thus avoiding the necessity of mental work on the part of the brick layer in choosing one brick after another, enabling a comparatively large number of packets to be handled upon a wheelbarrow, and eliminating the element involved in the picking and choosing done by the man who is loading a hod. Incidentally, when handling a hod, a hod-carrier must do considerably more foot-pounds of work than are necessary, and this accounts for something in the long run of a day's work.

(*b*) Quarried stone handled in skips, from the time it leaves the quarry until it reaches the rock crusher or the mason.

(*c*) Dump wagon box loaded with sand in a pit, lifted by a derrick and placed upon the wagon gear, lifted by a derrick at the concrete mixer and dumped into sand bin.

(*d*) Forms for concrete built in movable units—*e.g.*, sewer and tunnel lining centers.

(*e*) Girders for bridges and roofs, transported and handled as one piece.

(*f*) Bents for trestles, framed and joined while lying flat on the ground, and then placed in position as one unit.

(*g*) A further illustration is in the riveting together of as many bridge members as can be carried upon a car or combination of cars for transportation and which can be erected as a unit. Appreciation of this fact has led to the general use of plate girders wherever possible, since the erecting costs are low and by far the greater part of the riveting work can be done in the shop under the most favorable conditions for economic work.

Rule 16.—*Resolve each class of construction into the elements of work involved and study means of reducing the foot-pounds of each element.*

Thus shoveling involves: (1) Penetrating the mass, (2) elevating the material, and (3) moving it horizontally (overcoming the inertia of the shovel and the mass). By shoveling off an iron plate, the work of item (1) is greatly reduced, especially where the material is broken stone. By loading into skips, or very low wagons or cars, item (2) is reduced, or it may be largely eliminated caving the earth from a breast directly into a bucket or skip.

Rule 17.—*Ascertain the percentage of dead work done in conveying and elevating material, with a view to determining its relative importance and thus deciding upon what it is worth to reduce it.* In

all conveying, the work of moving the conveyor itself is "dead work." Thus, a wagon weighing 1 ton is used to transport 3 tons of load; therefore 25% of the work of transportation is "dead work." A shoveler uses a shovel weighing 5 or 6 lb. to shovel 15 or 20 lb. of earth, and thus performs 25% of "dead work" so far as elevating and transporting the earth is concerned. It might well pay, therefore, to substitute a higher-priced shovel made of alloyed steel, so as to secure a much lighter shovel that would reduce the "dead work."

Rule 18.—*Cultivate a strong esprit de corps by strengthening the personal relations between the management and the personnel and by keeping the "labor turnover" at a minimum.*

It is self-evident that a machine which is set up and operating can turn out a piece of work quicker and for less cost than one that has to be uncrated assembled, set up and adjusted. Thus it is that a working organization is more efficient than one that is newly "thrown together" and has not commenced to function properly.

Therefore, it is apparent that in order to carry out work with greatest efficiency, it is essential to maintain a working organization. This holds true not only as regards executives and superintendents but also in the case of foremen and in fact the laborers themselves.

One Contractor's Method for Holding Good Men.—Morton C. Tuttle, of the Aberthaw Construction Co., describes in *Engineering News*, April 8, 1915 a method for giving more regular employment to the men and thereby mitigating the hardships caused by the irregularity of employment which has been the principal evil to both employer and employee in the building trade.

After 15 years of successful progress from small beginnings, the Aberthaw Construction Co. found that, as is the case with every other company in the building business, certain men followed its work and looked to it for regular employment. Even on its scattered work, men preferred to travel in order to stay with the superintendents they knew rather than to stand their chances of irregular employment near home.

The principal difficulty which the men experienced came from the fact that wages vary considerably in different localities. There is usually a going rate of wage for a given occupation and these zones of varying wage are surprisingly close together, owing

to the fact that in the building trade most of the work in a given place is handled by the local contractors, who recognize a wage established in that section. We found that our men who had traveled naturally went to the jobs where the local wage was the highest, and we found that before a job was completed they tended to drift toward another job that was just starting or had several months to run.

In an effort to correct this condition, we issued "Record of Service Books" to a limited number of the best of our men. We guaranteed a book holder an agreed wage per hour wherever he worked for this company, and we agreed to give any book holder employment as soon as the company had a position available which he was capable of filling and we kept all bookmen informed of new work, and whenever new work came up we communicated with any of them who did not happen then to be employed by us.

When it was proposed to do this there was a feeling among our superintendents that bookmen were likely to neglect their work on the feeling that they had assured positions with the company. It was pointed out that the system of signing in and out on a job would prevent this, and each superintendent had the right to refuse to sign out any unsatisfactory man. As a matter of fact, the assurance of regular employment tends to make a man more faithful and easier to handle than is the floater.

The method of signing in and out with these books is as follows: When a man presents his book on a new job, the superintendent fills in the left-hand page, stating that he began work at a given date on a named job. At the end of the job, if the man's work had been satisfactory, the superintendent signs the statement that he quit work on a given date, and sends his book to the main office, where a sticker is attached to the right-hand page, and this is signed by an officer of the company, showing that the man has served properly on this job and that this book is good. The same process is repeated on future jobs. The book not only serves to give this man regular employment with our company, but is a first-class recommendation to any other company, who happens to value our opinion in regard to workmen in our line. In order that the book shall not be transferable, it contains at the front a very brief description of the holder, giving nationality, age, height, weight, color of eyes, color of hair, and his signature. A carbon copy of this page is torn out and held at the main office.

In 1910 an investigation was made as to the average earnings of carpenters and form builders in our employ. About the only information that could be obtained was from the men themselves, and this being a matter of memory was naturally incomplete and unreliable. The opinion was formed, however, that the average earning of the best men, who were paid 40 to 50c. per hour, was between $15 and $18 per week, seldom reaching the higher figure in the course of a year, owing to lack of work, interruptions on account of storms, and other delays incident to outdoor employment on an hour basis.

In February, March and April of 1911 we issued books to 21 men, and in the remainder of that year we issued three other books. In 1912 we issued 23 books, in 1913, six books, in 1914 five more—a total of 68.

The following table gives the number of weeks that each one of these men worked for this company with the maximum and minimum earnings per week:

TABLE SHOWING WORK OF BOOKMEN FOR YEAR 1914

Total number of men holding books		68
Canceled for inefficiency or for not being reliable	2	
Number of book holders moved to foreign countries or engaged in other occupations	9	
		— 11
Active book holders		57
Number of book holders away 1 to 6 months of their own accord and not available for work	14	
Number of book holders losing work due to inefficiency or for not being reliable	4	
		— 18
Number of men available for full year's work		39
Average time of employment of each of these 39 bookmen		50 weeks
Smallest employed period		40 weeks
Average yearly earnings		$1388.00
Average weekly earnings		27.76
Highest yearly earnings		1736.99
Lowest yearly earnings		886.92

These figures show that these men have earned wages that compare favorably with wages of men in less seasonable occupations and indicate the possibility of making profitable an occupation as irregular as that of the building trade.

The figures on the earnings of the various men show advantage to the employees. From the point of view of the employer, we can state that the result has been satisfactory to us, that we have probably obtained better return for our money from these men than from any others that we have employed. One has only to consider the extraordinary expense of teaching an inexperienced man a new trade to realize the fearful waste that there is in the building trade in picking up unorganized gangs and hiring, firing, and teaching, until a reasonable degree of efficiency has been obtained. The cost of an average reinforced-concrete building is made up of about 35% labor and 65% material. More serious than the inefficiency in the labor, itself, is the destruction and the waste of material. The employer's power of control is necessarily limited where a man expects for the rest of his life to drift from one job to another.

The gradation of punishments in the building trade is very crude, there usually being two electives—to call a man down severely, to which the man usually does not object, or to fire him, which in many cases makes very little more impression on him because he expects to be out of work a large part of the time and looks on such a discharge as simply meeting one of the evil days that he expects to meet frequently. With regularity of employment, proper and humane discipline can be brought into the building trade. The Record of Service Books used by this company offer an opportunity for this. For some misdemeanor or other a bookman who has completed his work may be given his book not signed by the superintendent, and yet the latter may not consider the matter serious enough to cancel the book altogether. This omission puts the man on the same basis as a man without a book except that if he can get located again and properly signed out he becomes a book holder again in good standing. The lay-off of graded length, the threat of discharge or lay-off, and the criticism of work in which a man takes pride, all become more effective when the employee is with an organization offering him steady employment.

CHAPTER III

PIECE-RATE, BONUS AND OTHER SYSTEMS OF PAYMENT

The fundamental law of management involves that payment for work done shall be proportionate to performance—that is, an increased number of units of work done by a man shall result in his receiving increased pay. The ordinary wage system is based upon this law, but only in a very crude manner, since it throws men into large groups or classes, individuals of which receive the same pay, or practically so.

We shall now consider some of the various methods that aim to recompense a workman in proportion to his performance.

Profit Sharing.—According to the method of profit sharing, each individual receives not only his wage but a pro rata of any profits that arise from the business. Either quarterly, semi-annually, or annually, the profits of the business are estimated, and a certain percentage of these profits is distributed to the workmen and their managers. Often this distribution of profits is confined to the managers only.

While this is an improvement over the wage system, it violates the sixth law of management—namely, the law of prompt reward. The imagination of the ordinary workman is not enough to maintain his interest in his work at the high pitch necessary to enable him to do his very best. Moreover, any community interest in a commercial enterprise lacks sufficient stimulus. It requires a more direct, personal interest in the outcome to arouse a man to action.

Profit sharing, whether by the payment of profits direct, or in the form of dividends on stock held by the workman, is, at best, only a moderate step in advance of the ordinary wage system so far as the average workman is concerned.

Piece-rate System.—According to the piece-rate system, each workman is paid a certain stipulated amount per unit of work done by him. If all managers were fair in their dealings with workmen, and if all workmen were reasonable, the piece-rate system would be almost ideal as a method of paying men

wherever the work is of a character that admits of measuring individual performance. Due to hoggishness on the part of managers and unreasonableness on the part of workmen, the piece-rate system usually fails to accomplish the desired end.

Having established a piece rate of, say, 20 cts. per cubic yard for shoveling earth into wagons, on the assumption that 15 cu. yd. per day per man is a fair output, it requires more than ordinary foresight and liberality not to cut the rate when laborers begin to load 25 cu. yd. a day. The typical contractor will then begin to reason about as follows: "These men have been soldiering on me in the past. I always thought so; now I know it. Well, now that I do know it, and they know I know it, they will have to work at this rate hereafter or get out. What's more, I am not going to be gouged out of an extra two dollars a day, either. If they make 95 cts. extra a day, it's more than they ever got before, and it's all they are entitled to, so we will just drop that 20-ct. rate down to 15 cts. That will satisfy them." But the trouble is that it doesn't. The men immediately become angry, and rightly so. If they do not quit entirely, they lose all further ambition and desire to increase their output, knowing full well that the piece-rate will be so cut as to enable them to earn only a slight advance over their original day's wages.

This experience has been so general that nearly all labor unions have put a ban on the piece-rate system. Bear in mind, however, that the piece-rate system is not inherently at fault, and that it is used with great success in many places where the management has been liberal and far-sighted.

On piece-rate work that involves the use of machinery, it is manifest that any improvement in the machinery which enables the men to turn out more units daily, should be accompanied by some reduction in the piece rate. Workmen, however, are usually unreasonable and oppose any reduction in the rate. This unreasonableness disgusts the manager as much as a manager's hoggishness disgusts the workmen. If the manager goes to the expense of buying and operating improved machinery, he is entitled to his share of the increased profit, but the workman is not quick to see things in that light.

Obviously, any piece-rate system is productive of more or less friction between managers and men, yet no system is free from some friction. Probably the chief function of the labor

unions of the future will be to protect workmen in agreements with managers, and to be parties in arriving at what those agreements shall be.

The Bonus System.—This system involves paying each workman a daily wage plus a piece rate on each unit in excess of a stipulated minimum. This piece rate on excess product is called a bonus. For example, a laborer receives \$2.50 a day for shoveling earth, and on each cubic yard in excess of 15 cu. yd. shoveled per day he receives a bonus of 10 cts. If he shovels 25 cu. yd., he receives \$2.50 + (0.10 × 10) = \$3.50.

The bonus system is really a piece-rate system with a guarantee of a certain minimum wage. Slight though this difference from the piece-rate system is, it is generally viewed with more favor by workmen.

The Differential Piece-rate System.—The principle of this system is to pay a certain piece rate up to a certain output per man, and a higher rate (but still a piece rate) above that output. Applied to drilling, for example, the drill runner would be paid, say, 9 cts. a foot up to a performance of 50 ft. per day, and 12 cts. a foot for every foot above 50. The helper might still be paid \$3 a day straight, but it is wise always to give him also a contingent interest in the result of his work.

This system, which was devised by Frederick W. Taylor, is described in the following paragraphs.

General Plans on Which the Taylor Differential Piece-rate System Is Based.—There are two fundamental assumptions on which the layout of any extensive system of labor must be predicated:

I. A man can do his theoretical best if continually instructed and coached, but not otherwise.

II. A man will do his theoretical best if adequately remunerated, and not otherwise.

It is assumed in the expression of "theoretical best" that the right kind of theory is meant. A theoretical best that is founded on a lost theory is not here considered. The application of these assumptions depends upon the following fundamental principles of practice as outlined by Mr. Taylor:

1. A large daily task that must not be impossible.
2. Standard conditions, so that work can be accomplished with certainty.
3. High pay for success.

4. Loss in case of failure.

5. The task set must be so difficult ultimately that none but a first-class man can do it.

The first of these principles is based upon the fact of observation that if you give a man a specific thing to do in a definite amount of time he will do it more efficiently and more accurately than if you give him the same thing to do and he is supposed to take "any old time" to do it. This fact is so old and is so thoroughly grafted upon the minds of all men who do work that it seems unnecessary to argue in its favor; that it has not been more generally applied is due to the lack of appreciation of how easy it is to apply it. Hence, the rare and useful corrollary to this proposition—namely, that the duration of a special task, for the maximum efficiency, will be so short that a man can keep his mind continually concentrated upon the speed with which he is progressing, without becoming mentally exhausted. In practice it is sometimes possible to apply this principle without actually knowing what a reasonable task is by taking two men of about equal capacity and setting them to do the same kind of work in competition; then the task that each man has is to beat the other fellow, which, if he is gifted with ordinary red blood, he proceeds to do. In the course of a comparatively short time he finds out whether he can beat him, or not, and as soon as it is definitely settled which man can beat the other they both stop trying. It is possible, before they get through competing, to determine how fast they have been working, which is the really valuable point about competition.

Another method for ascertaining a man's possible output, and one which is mostly used in shop work, is to divide up the time of any process into its component parts. The process of rock drilling, for example, can be divided into the following component parts, starting with the drill all set up and ready for work:

1. Turning on the steam.

2. Drilling to the limit of the first bit.

3. Turning off the steam and picking up wrench.

4. Loosening the bit in the chuck, involving the unscrewing of two nuts and the turning of the chuck.

5. The raising of the chuck by hand to release the bit, assisted by the helper, who during the rest of the process is winding up on the feed screw.

6. Drawing out the steel from the hole.
7. Laying the steel down and picking up the pump.
8. Pumping out the hole.
9. Laying down the pump.
10. Picking up the next bit.
11. Dropping down into the hole.
12. Raising piston and slipping over the head of bit.
13. Picking up wrench.
14. Tightening nuts, involving ½ revolution of the piston about its axis.
15. Dropping wrench and turning on steam for the first five strokes.
16. Opening up throttle and slowly working drill up to full speed.

By the use of a stop watch a standard time for each of these processes, depending upon the conditions, can be obtained, and the total time, being the sum of these, will represent the entire cycle of the process. The problem consists in adding together the fastest times for each element to get the fastest possible time for the whole cycle. The results from such an investigation have never failed to be astonishing in the last degree.

1. In the process in which the mental effort required is large, care must be taken to allow a man a sufficiency of rest. For example, a man can "chin himself" of a horizontal bar quite rapidly for about 10 revolutions, so to speak, but the next 10 are a different matter.

2. The success of the Taylor method depends very largely upon standardizing conditions. To use the illustration of drill work, the time required to pick up and place in position a drill bit four feet long is considerably less than the time required to pick up and place in position a drill bit ten feet long, and the performance with the 10-ft. bit cannot be accurately predicted upon observation with a four-foot bit. To use a still more pointed illustration, the time required to drill down two feet through the different kinds of rocks varies greatly, and it also varies greatly in some of the rocks when a water jet is used. From the above it seems clear that the precise conditions should be known in all cases. Some of the conditions will be common to all similar classes of work and other conditions will depend upon the local features. The two illustrations mentioned in the paragraph above are taken from two different classes of condi-

tions. The study of one means the study of drill work in general; the study of the other means the study of the work on the particular job to be attacked.

3. If a man is going to take orders and alter his way of doing work, doing it in a manner that is not only new but at first disagreeable, and when, involved with this, he is required to perform what seem to him a lot of unnecessary and rather ridiculous "stunts," he has got to have extra pay; if in addition to these other things he is required to exert himself to the utmost the extra pay will have to be very substantial. The whole proposition of the Taylor system is that under proper instructions with these conditions the amount of extra work that he will be able to do will be considerably more in proportion than the amount of the extra pay. The amount of extra pay that he must receive in order to do his best is from 30 to 100% more than what he originally was getting. There is a certain point at which still more pay will not result in the accomplishment of a corresponding increase in work for two reasons: In the first place, there is a limit to what a man can do, and in the second place, if his money comes too easily or he gets too much of it, he becomes lazy. Just here it is proper to observe that the result of work of this kind is to make a man more sober as well as more industrious for two reasons: He cannot drink much and hold the pace, and the effort and attention required to get his work done decreases his desire for alcohol. Since July, 1920, the difficulty of obtaining alcoholic beverages has greatly increased, to the general benefit of industry.

4. If a man does not succeed in keeping up to the standard performance, one of two situations must obtain:

(*a*) If his lack of success is due to special conditions, lack of instruction, lack of practice, or both, owing to break-downs of machinery or tools, or to irregularity in the material, or to the weather, it must not be counted against his future, but he should himself receive less money than he would if he had succeeded. In other words he must try, and he must try successfully in order to earn his extra money.

(*b*) If this failure to achieve extra money is because he is constitutionally unable to do what he ought to be able to do, then the only thing is for him to give place to a better man. Mr. Taylor has reduced the thing to the simple proposition of considering only two classes of labor—namely, the first-class man

and the man who is not first-class. It is not difficult to determine which is which.

5. After months and years of development and instruction the pay can be made so high as to attract the very finest class of labor in the world and the task can be made so exceedingly difficult that none but the very highest class men can hold their jobs, and at this point it would seem that the ordinary limitations of the human machine had been reached. From a consideration of historical facts it does not seem as if there were any limit to what a man can accomplish industrially, but there is a limit to what he can do physically. Further improvement must depend upon methods, machinery, and special cooperation.

As Mr. Taylor expresses it, the differential piece rate not only pulls a man up from the top but it pushes him equally hard from the bottom. We quote from a paper entitled "A Piece Rate System," read by Mr. Taylor before the American Society of Mechanical Engineers in 1895: "The first case in which a differential rate was applied, during the year 1884, furnishes a good illustration of what can be accomplished by it. A standard steel forging, many thousands of which are used each year, had for several years been turned at the rate of from four to five per day under the ordinary system of piece work, 50 cts. per piece paid for the work. After analyzing the job, and determining the shortest time required to do each of the elementary operations of which it was composed, and then summing up the total, the writer became convinced that it was possible to turn 10 pieces a day. To finish the forgings at this rate, however, the machinists were obliged to work at their maximum pace from mornings to night, and the lathes were run as fast as the tools would allow, and under a heavy feed. (Ordinary tempered tools 1 in. by ½ in. made of carbon tool steel, were used for this work.)

"It will be appreciated that this was a big day's work, both for men and machines, when it is understood that it involved removing, with a single 16-in. lathe, having two saddles, an average of more than 800 lb. of steel chips in 10 hr. In place of the 50-ct. rate, that they had been paid before, they were given 35 cts. per piece when they turned them at the speed of 10 per day, and when they produced less than 10, they received only 25 cts. per piece.

"It took considerable trouble to induce the men to turn at this high speed, since they did not at first fully appreciate that it was the intention of the firm to allow them to earn permanently at the rate of $3.50 per

day. But from the day they first turned 10 pieces to the present time, a period of more than 10 years, the men who understood their work have scarcely failed a single day to turn at this rate. Throughout that time until the beginning of the recent fall in the scale of wages throughout the country, the rate was not cut.

"During this whole period, the competitors of the company never succeeded in averaging over half of this production per lathe, although they knew and even saw what was being done at Midvale. They, however, did not allow their men to earn over from $2 to $2.50 per day, and so never even approached the maximum output.

"The following table will show the economy of paying high wages under the differential rate in doing the above job:

Cost of Production per Lathe per Day

Ordinary System of Piecework		Differential-rate System	
Man's wages	$2.50	Man's wages	$3.50
Machine cost	3.37	Machine cost	3.37
Total cost per day	$5.87	Total cost per day	$6.87
5 pieces produced; cost per piece	1.17	10 pieces produced; cost per piece	.69

"The above result was mostly though not entirely due to the differential rate. The superior system of managing all of the small details of the shop counted for considerable.

"The exceedingly dull times that began in July,1893, and were accompanied by a great fall in prices, rendered it necessary to lower the wages of machinists throughout the country. The wages of the men in the Midvale Steel Works were reduced at this time, and the change was accepted by them as fair and just.

"Throughout the works, however, the principle of the differential rate was maintained, and was, and still is, fully appreciated by both the management and men. Through some error at the time of the general reduction of wages in 1893, the differential rate on the particular job above referred to was removed, and a straight piecework rate of 25 cts. per piece was substituted for it. The result of abandoning the differential proved to be the best possible demonstration of its value, Under straight piece work, the output immediately fell to between 6 and 8 pieces per day, and remained at this figure for several years. although under the differential rate it had held throughout a long term of years steadily at 10 per day"

The most disappointing feature about the introduction of a system of management modeled after the Talyor plan is that such introduction always meets with the opposition of the "has

beens." It seems that after a man has reached a certain age he becomes unwilling or unable to assimilate new ideas, and when he is confronted with the proposition that he has been doing work for 20, 25, or 30 years according to a method that was not and is not economic, the news strikes him with a shock that is painful. He objects, in the first place, that the new scheme cannot be right, because if it had been right he would have known all about it before; but, after it has been demonstrated beyond cavil that the new scheme is right, he is likely to work himself up into a stubborn and absolutely uncompromising policy of obstruction. The new scheme may be all right, but it is executed with a lot of "frills" which are not practicable; the new scheme involves too much superintendence and too many people who get well paid; the new ideas may have been tried out a few times lately with success, but his old ideas have been in use for a hundred years, and more people have earned their bread and butter by the old ideas than by the new ones; finally, with his back against the wall, having committed himself with absolute rigidity to the proposition that the new scheme must fail, he feels that he will stultify himself in the eyes of his employees and of his friends if the new scheme does not fail. This all results, in the worst cases, in a determined and absolutely uncompromising effort to make it fail. However, so far as the authors know, it never has failed, and it has been applied time and time again. How to treat the obstructiveness is a matter of individual tact and judgment that must be applied upon the merits of each case and does not come within the scope of this volume.

The differential piece rate should never be installed until after thorough time studies have been made of the work, so that a first-class man's capacity can be predicted with accuracy.

The Differential Bonus.—This is based on the same principle as the differential piece rate while guaranteeing to a man a fixed minimum of wages. We applied it in drilling work, in 1908, offering the men 2 cts. per foot drilled for every foot above 70, and 3 cts. for every foot above 80 per day, while at the same time paying them their regular rate of wages.

Task Work With a Bonus.—H. L. Gantt, one of Taylor's pupils, invented a system of differential payment known as "Task work with a Bonus," which has been very successful in practice and has great flexibility of application under varying conditions. The workman under this system is paid his regular

day's wages in any event and a certain lump bonus if he succeeds in accomplishing the standard task. The amount of this bonus is usually about one-third of his regular wages. Mr. Taylor says that this system is especially useful during the difficult and delicate period of transition from the slow pace of ordinary day work to the high speed which is the leading characteristic of good management. During this period of transition in the past, a time was always reached when a sudden leap was taken from improved day work to some form of piece work; and in making this jump many good men inevitably fell and were lost from the procession. Mr. Gantt's system bridges over this difficult stretch and enables the workman to go smoothly and with gradually accelerating speed from the slower pace of improved day work to the high speed of the new system.

The Premium Plan.—This is the term used by F. A. Halsey to describe what Mr. Taylor calls the Towne-Halsey system. It is based on the proposition of paying a bonus for achieving an estimated performance, the means to be employed and the methods being left to the ingenuity and initiative of the men, rather than to the management.

Principles Governing the Fixing of a Piece Rate or Bonus.—We are probably well within limits when we say that the average workman engaged on construction work under the wage system is capable of increasing his output 70% if given sufficient incentive to do so, and this without the least physical injury to himself. When it is desired to ascertain how much work men are capable of doing, one of the best plans is to conduct a contest between two or more men, or two or more groups of men, a substantial prize being offered for the best performance. Such a contest should usually extend over several consecutive days, so that it will not be a mere sprint, but a fair endurance test.

In Gillette's "Rock Excavation" are given the rate of progress and cost of driving the Croton Aqueduct tunnel. The men in one of the headings determined to "break the record" for one week's run, and drove 102 lin. ft. of heading in 7 days, at a total cost of $2.93 per cubic yard for labor, fuel, explosives and other supplies. The average weekly progress prior to that time was 47 lin. ft. and the average cost was $5.32 in the same material. In brief, these men doubled their average speed for a whole week when working with an incentive, although that incentive was merely pride in establishing a record.

Taking another example from the same book (page 360), we find that when miners in the War Eagle Mine, at Rossland, B. C., were paid by the lineal foot of drill hole, gangs of four men drove 97.5 lin. ft. of "drift" (or small tunnel), as compared with an average of 50.8 lin. ft. per month under the wage system. Under the wage system each miner earned $3.50 a day; while under the "hole contract system" (which is a piece rate system with lineal foot of drill hole as the unit), each miner earns $4.25 a day. Under the wage system the mining cost to the company was 86 cts. per ton of ore, while under the "hole contract system" it is 48 cts. per ton.

These examples are cited not only to show the wonderful possibilities of economic performance under any system whereby the men are paid according to their output, but to indicate in a general way what piece rate or bonus can safely be adopted to start with.

In the last case cited, it is the opinion of the authors that the mine managers did not give the miners as high a piece rate as they were entitled to receive. Surely when a man doubles his output without any change in the plant or tools, he is entitled to an increase more than 20% in excess of his previous income.

If a competitive contest to disclose the workmen's abilities is not practicable, the authors assume that the output probably can be increased 60 to 70% over the output under the wage system, wherever the output depends mainly on the skill and strength of the workmen. In drilling rock, for example, if the average output of each drill is 60 lin. ft. under the wage system, then, in all likelihood, it can be increased to nearly 100 ft. under a bonus system. The driller who receives $4.50 a day under the wage system is really earning 7.5 cts. for each of the 60 lin. ft. If it is planned that he shall increase his income 50%, he will receive $6.75 for the assumed 100 lin. ft. of hole. Hence his piece rate would be 6.75 cts. a foot, or his bonus would be $2.25 on 40 lin. ft. (60 lin. ft. being taken as the standard minimum performance), which is equivalent to a bonus of 5.625 cts. per linear foot on every foot in excess of 60 ft. to be added to a daily wage of $4.50. At first sight it seems that the contractor gains only 1.875 cts. per linear foot for the 40 lin. ft. on which a bonus is paid, or only ½ ct. per lineal foot on the entire 100 ft. The fact is that the contractor gains much more, not even considering the

wages of the driller's helper, for the daily plant charges on the drill remain almost constant, regardless of the output. If fuel, fireman, interest, repairs, depreciation, foreman, etc., are $4.00 per day per drill, these fixed charges amount to 6.66 cts. per linear foot of hole when the output is only 60 lin. ft. a day, as compared with 4 cts. per linear foot when the output is 100 ft., or a saving of 2.66 cts. per linear foot. Wherever a plant of any considerable value is used, it is clear that it would be profitable to double the pay of the workmen if they could double the output of the plant, for the unit saving in plant charges alone would amount to a handsome profit. This is upon the assumption that the fuel bill remains practically unchanged by the increased output, and it seldom is materially affected by increased output on contract work.

How to Fix the Wage Rate.—When a piece rate or bonus rate is to be established it is of great importance that it be established with correctness, so that it will not be necessary to alter it subsequently, since nothing is likely to produce more dissatisfaction among the men than a change of base on the part of the management, which gives the men the impression that they are being imposed upon. A fairly safe rule is to pay a piece rate which will insure to the average workman under average conditions with average effort the ordinary wages which he could earn by the day. The trouble with this basis is that after the piece rate has been in operation a little while the earnings per man increase so much that the employer begins to think that the piece rate is too high, and then he attempts to readjust it with disastrous results. After long experience in this subject the only thoroughly satisfactory method of fixing the wage rate that we know of is to guarantee to the men not less than the "prevailing rate of wages," and preferably a little more than the prevailing rate of wages, as a daily or hourly or monthly rate, and on top of this to pay them extra for extra accomplishment. To make men do their level best, an increase of from 30 to 40% of this regular wage is necessary.

Harrington Emerson developed an excellent way of grading bonuses while reorganizing some of the work at the Toledo shops of the Atchison, Topeka & Santa Fe Railroad in 1907. Mr. Emerson first determines what a man's theoretical practicable efficiency is, and this he calls 100% efficiency. Thus, if a first-class man ought to be able under the standard conditions to

make 100 pieces of a certain pattern per day, a man who succeeds in making 80 is rated at an efficiency of 80%. The bonuses are graded as follows: A man whose efficiency is 67% receives the regular rate of wages. If his efficiency is 80% he receives about 3½% of the regular rate of wages as a bonus. When his efficiency is 90% he receives a 10% bonus. At 100% efficiency he receives 20% bonus and from then on he receives 1% additional bonus for every per cent increase in efficiency. Thus if he can do 50% more work than the standard man or if his efficiency be 150% he gets 70% bonus.

It is well to avoid starting off on any fixed piece rate in outside construction work, as thereby it is possible to steer clear of a great many obnoxious preconceived notions of the men who may fear that the management is getting up a scheme to deprive them of their just compensation.

In applying any rule of this kind it is important to start off, as a rule, with one man, or small group of men, at a time, gradually expanding the system to include the whole job. Don't forget that the expansion must absolutely be gradual and at first very slow.

The "Stint" System.—Having decided the number of units of output that may be accomplished in a day or in a week, a "stint" or task may be assigned to an individual or to a gang, with the promise that when the "stint" is performed the workmen will be required to do no more that day or that week. By this method, the reward consists in a gift to the workman of all time that he may save by working vigorously. The authors have frequently found that a gang would finish its day's stint 3 hr. before the regular quitting time, or that, if the "stint" was a week's work, the men would save 1½ to 2 full days. There are some advantages of this method over the ordinary wage system. For example, it gives spare time in which to make repairs to the plant while the workmen are not using it. It makes the men more cheerful and ambitious while working, for they look forward eagerly to the hours thus gained for recreation. Hence a large "stint" can be set and the men will do more units of work under it than under the regular wage system.

The "stint" system has the obvious disadvantage that it does not yield the workman an increased income. Therefore it is only a short step in the right direction. We mention it in this chapter principally because it is often a good method to adopt preparatory

to adopting a bonus system, for it serves to show, in a measure, what the men are capable of doing, and thus acts as a guide in deciding what the bonus shall be.

Over 40% Greater Output per Man by Piecework in contrast to the ordinary force account method was recorded in California by Everett N. Bryan, Chief Engineer of the Waterford Irrigation District, California, and described as follows in *Engineering News Record:*

Yardage output per man in excavating for road construction in California was 10.9 cu. yd. and 14.3 cu. yd. by piecework, compared with 6.8 cu. yd. and 10.9 cu. yd. by force account. On excavation for irrigation structures, the piecework output per man was 7.2 cu. yd., as compared with a best record of 6.3 cu. yd. by force account. In both comparisons the conditions favored more rapid excavation on the force-account jobs.

The road excavation amounted to 59,027 cu. yd. of loam, "dobe" and cemented gravel, containing in places large percentages of loose rock. Loosening by blasting was necessary to get the best results. All excavation was pick and shovel work, and the material was loaded into cars.

The force-account excavation amounted to 12,283 cu. yd. One cut of 9,000 cu. yd. had a maximum depth of 25 ft. This was handled by driving a center drift at the bottom and trapping as much as possible of the material into cars. The excavation in the smaller cuts was shoveled. Competent foremen were in charge in all cases. The average output, including drilling, blasting, drifting, mucking, transporting and dumping was 6.8 cu. yd. per man per day. Counting labor in drifting and mucking alone, the output per man per day was 10.9 cu. yd.

Nine station gangs excavated the remaining 46,744 cu. yd. Part of the material was trapped into cars in center drifts at the bottoms of the deeper excavations, part was trapped into cars beneath lean-to platforms against the faces of the excavation, but the larger part was shoveled directly into the cars. Generally, the conditions were not so favorable to rapid progress as they were in the 12,280 cu. yd. of excavation that was done by force account.

The output per man per day for the nine gangs was, however, 10.9 cu. yd., including all operations, and 14.3 cu. yd., including only labor in drifting and mucking.

In excavating for irrigation structures the force-account

operations were divided into two parts. About 1,339 cu. yd. of excavation was for 28 canal structures and was contained in pits not over 30 in. wide, which were shallow enough to be dug without reshoveling. There was some hardpan in the pit bottoms and the top soil had to be loosened by picking. Very little blasting was necessary. The average output was 3.94 cu. yd. per man per day. The second part of the force-account excavation consisted of trenches for five inverted siphons, and amounted to 1,019 cu. yd. The material was not inconvenient to handle, there being very little cemented gravel requiring blasting. The output was 6.3 cu. yd. per man per day.

On another part of the work piecework contracts were let for the trenching for three more inverted siphons. The excavation amounted to 2,469 cu. yd. of which 2,218 cu. yd. were in one trench 4½ ft. wide and averaging 5½ ft. deep. The other two trenches were of smaller cross-section, the smallest one being 2.25 ft. wide and averaging 3.2 ft. in depth. The smallest trench was very hard at one end and required blasting; the middle-sized trench was handled entirely without powder, and the largest trench required the use of powder throughout. An average of 0.69 lb. of powder per cubic yard was used, and the bottom was carefully trimmed with picks to leave a smooth surface on which to lay the concrete pipe. The average progress per man per day, including drilling, shooting, picking, shoveling, and forge work, was 7.8 cu. yd.

In some cases it is not practicable to compensate an entire gang on a piece-rate basis, but it is often possible to engage one or more of the men to undertake the work on such a basis, if the employer will pay wages to the other men and deduct the cost thereof from the total sum earned by the gang. This plan is applicable to many lines of work where the total cost is not sufficient to justify an attempt to let contracts in the usual way. The work requires less watching than when done by day labor, and is generally accomplished with greater satisfaction to both employer and employee.

Some Striking Reductions in Costs Effected by the Piecework System.—In the *Electric Railway Journal*, April 6, 1912, is an excellent article descriptive of the methods and results of applying unit timing and piece rate payments in the car shops of the Interborough Rapid Transit Co., which operates the subways and elevated roads in New York City.

The result has been to cut the labor cost of car maintenance fully one-third, and to increase the wages of the workmen more than one-third. In many classes of maintenance work the output of the men has been more than doubled.

To those who have themselves applied scientific piece rate and bonus systems of payment, there is nothing unexpected in such a result. The following are some of the statements in the above mentioned:

The result of the introduction of this piece price was to reduce the cost of stripping and trimming [cars] to approximately 40% of the cost existing under day-work payments, notwithstanding that the wages of the workmen were increased about 40%.

The introduction of these [piecework] prices [for equipping motor cars] effects a saving in labor costs amounting to 41% for conduit and pipe work, 49% for electrical work and 52% for carpenter and machinists' work.

The Interborough Co. has adopted two methods of payment, one being a straight piecework and the other a bonus method. For simple routine operations that can be analyzed accurately, payments are invariably made by the piece. For complicated operations in which the elements of cost differ considerably on different jobs, a bonus system of payment is used. Car cleaning, motor wiring, installation of new equipment on cars, etc., are paid for by a bonus system.

Both systems of payment have one important element in common: They are based upon unit timing with a stop watch. Each "job" is analyzed into its elementary operations, and an average workman is timed repeatedly on each operation until a fair average time for each operation is obtained. Then, based on this unit timing a "key" price is assigned to each operation. A summation of the products of the "key" prices by the number of operations gives the piece price for the given job. An illustration will suffice to indicate the method of arriving at "key" prices and piece prices.

In the problem of determining the piece price for stripping a subway motor car of a certain type, it was found that 1,318 wood screws must be taken out. While the screws vary in length, stop watch timing disclosed the fact that the size of the screw does not appreciably affect the time of removing it, for most of the time is spent in the initial effort of starting it. The

location of the screw, however, does affect the time, screws for seat backs, for example, being much more difficult of access than screws for sash locks.

The time of the operation of removing screws of each class includes also the time of removing the piece held by the screws, where the piece is small, but, where the piece is large—a window sash, for example—a separate time for removing that piece is ascertained. To the actual time of removing screws and pieces, is added 33⅓% to provide for rests; or the equivalent is accomplished by adding one-third to the hourly rate of pay. If the hourly rate of carpenter pay is 24 cts., then the actual time per piece is multiplied by one-third more than 24 cts., or 32 cts., to get the piece price, thus providing for a rest period equal to one-third the time of actual work.

The following is a condensed summary of the piece price of stripping a certain type of subway car:

Items Removed	Cents
28 window sashes at 0.43 ct.	12.04
2 signal cards at 2.60 ct.	5.20
1,088 sash screws and other screws at 0.045 ct.	48.96
54 sash rod screws and other screws at 0.08 ct.	4.32
176 door and seat screws at 0.12 ct.	21.12
Total piece price	91.64

The nearest whole cent is taken as the "piece price," so, in this case, the piece price would be 92 cts. for stripping the car. The "key" prices in the above example are 0.43 ct. for window sashes, 2.60 cts. for signal cords, etc. As above stated, this piece price payment of workmen engaged in car stripping has resulted in decreasing the cost to the company by 40% and increasing the workmen's income by 40%.

The foregoing is an illustration of the piecework pricing where only manual labor is involved. An illustration of machine work pricing will next be given, a car sill being selected for illustration.

A wooden end sill, 3 by 12 in. by 8 ft., must be perforated with 20 holes and must have four "gains" cut in the side. The total piece price for the labor on the sill is as follows, based on an hourly rate of 36 cts.:

Item	Cents
22 ft. B. M. dressed in a planer at 0.04 ct.	0.88
Cut to length with cross-cut saw	0.75
Laying out with templet	3.20
Boring holes with machine	2.25
Gaining, four gains	2.11
Sawing ends with hand saw	2.10
Total	11.29

The 2.25-ct. price of boring the 20 holes is derived thus:

Item	Cents
22 ft. B. M. handled at 0.033 ct	0.726
68 in. bored (20 holes) at 0.01 ct	0.680
15 longitudinal shifts (6-in.) at 0.035 ct	0.525
3 cross shifts at 0.02 ct	0.060
1 carriage shift at 0.26 ct	0.260
Total boring price	2.251

The 2.11-ct. price for cutting four gains is estimated as follows:

Item	Cents
22 ft. B. M. handled, at 0.033 cts	0.726
12 cuts, at 0.06 cts	0.720
11 longitudinal shifts, at 0.06 cts	0.660
Total gaining price	2.106

The machines used in boring and gaining are a heavy three-spindle boring machine with hand-operated carriage, and a horizontal gainer carrying a 5-in. head with a power operated table 20 in. wide.

The item of "handling" the 22 ft. B. M. includes lifting the piece on and off the table or carriage and setting the piece for the first cut. A "longitudinal shift" is a shift of the table or carriage; and the time varies slightly with the distance shifted, so that each length of shift must be timed to establish a correct "key" price. A "cross-shift" is a shift of the bit across the timber without moving the table. A "carriage shift" is a shift of the timber on the carriage, such as moving or turning the timber.

To each piece price for a given sort of work is assigned a "contract number;" thus the number 951 designates "Westinghouse air compressor—strip, clean, repair, assemble and test," for which the piece price is $3.50.

On daily report cards are entered the names and "pass

numbers" of the workmen, the car or job number, the "contract number," the number of pieces of work performed, the hours worked, and the amount earned.

As above stated, a bonus system of payment is applied to certain kinds of work that either have not been, or cannot be, very accurately analyzed and timed. But even when a bonus payment is to be made, piece prices are first determined in the same general way as for piece work payment, and to these piece prices about 20% is added to secure the "bonus list price."

Then the standard day's work consists of such a number of pieces that, when multiplied by the "bonus list price"; will yield the ordinary day's wage. For every additional piece turned out in excess of the standard day's work, the workman receives *half* the "bonus list price" as his bonus, which is added to his standard daily wage. By this method, if the workman doubles his day labor output, he receives one and eight-tenths times as much daily pay; so that this form of bonus payment is not quite as advantageous to the workman as a straight piecework payment under which he would receive double pay for double output.

In 1907, prior to the adoption of the bonus system, it cost the company 14 cts. to clean each car at the barns. It now costs 5.6 cts. per car, under the bonus system, and the workmen earn 30% more per day than they formerly earned under the old daily wage system. In car cleaning the men work in gangs, and the total bonus earned is prorated to the men in the gang.

Having once adopted a piece price, no cutting of the price is made unless new methods of doing the work are developed. This insures the continued cooperation of the workmen, and their confidence in the good intentions of the company.

It may be interesting in this connection to quote a few sentences from the recent report of the congressional committee that "investigated scientific management," and found it mainly a tinkling cymbal.

By the stopwatch you may be able to determine the time in which a piece of work can be done, but you do not thereby alone determine the length of time in which it ought to be done. The time study of the operations of any machine can be made with a reasonable degree of accuracy, because all of the elements can be taken into consideration in making the computation. A machine is an inanimate thing—it has no life, no brain, no sentiment, and no place in the social order. With a workman it is

different. He is a living, moving, sentient, social being; he is entitled to all the rights, privileges, opportunities, and respectful consideration given to other men. He would be less than a man if he did not resent the introduction of any system which deals with him in the same way as a beast of burden or an inanimate machine.

And then follows much more of the same molding of snowmen in the image—the very distorted image—of "scientific management," as target for rhetorical periods.

Piecework neither makes men "beasts of burden" nor does it reduce them to the status of "inanimate machines." On the contrary piece work, convertry work into a game of skill, and aminate the machine-like laborer. That it operates to the great advantage of both employer and employee is well illustrated in the results secured in the shops of the Interborough Rapid Transit Co., as it has resulted in scores of industrial establishments.

Application of Wage Bonus Plan to Construction Operations.—In the instances to date where a successful plan of paying bonuses to laborers and foremen on outdoor work has been evolved, the basis of the system has usually been the standard time and bonus method of wage payment.

This plan is based upon the establishment of a standard time for the performance of a certain amount of work, and when this set task has been accomplished, the payment of a substantial bonus for additional work done. In this way the workman is assured of a fair wage every day even should conditions be unfavorable for a large output, and then at other times he is enabled to earn higher wages than would otherwise be possible.

Since the work done by a gang of men is the result of joint effort, the performance percentage for the entire gang is the factor that determines the bonus for each man. Further, the bonus percentage for the gang is the bonus percentage for the foreman and is applied to his salary for the pay period, thereby furnishing him with an effective incentive to secure rapid and efficient work. In a statement prepared by W. C. Nisbet of the Emerson Engineers, New York City, for the Committee on Methods of the Associated General Contractors, some applications of this time standard and bonus method in construction operations are cited. The statement is printed in the January *Bulletin* of the Association, from which the matter following is abstracted.

Hand Excavation on Railroad Cui.—Digging a short ditch through a railroad cut, with trains in operation. Hand work loading into small dump cars, hauled out by boy and mule.

Those in charge decided on the method and a numbeer of men who could work to advantage, then set the time standard, which was, let us say, five men for 13 days, or 65 man days. Then suppose the job actually took 70 man-days—the efficiency attained was 65 divided by 70, or 93%. This would pay a bonus to all hands, including foreman and mule driver, of 13% on their wages, as reference to the second table below will show.

	Rate per day	Time	Wages	Bonus	Total
Foreman	$5.00	14 days	$70.00	$9.10	$79.10
Laborer	4.00	14 days	56.00	7.28	63.28
Boy	3.00	14 days	42.00	5.46	47.46

If one laborer at $4 per day laid off ½ day, his earnings would then be $4 times 12½ days, or $50 in wages, with a bonus of $6.50, or a total of $56.50

The bonus percentages for various efficiencies are as follows:

Efficiency %	Bonus %	Efficiency %	Bonus %
75	1.0	90	10
76	1.6	91	11
77	2.0	92	12
78	2.4	93	13
79	2.8	94	14
80	3.3	95	15
81	3.8	96	16
82	4.3	97	17
83	5.0	98	18
84	5.5	99	19
85	6.0	100	20
86	7.0	101	21
87	7.6	102	22
88	8.4	103	23
89	9.2	105	25

Surfacing New Railroad Track.—Ballast and surface a piece of new railroad track: Suppose the grade is finished, ties placed, rails spiked and bolted and ballast dumped on the track. Gang of 14 men with a foreman comes on the job to raise and to surface to grade stakes. The standard is, let us say, 0.055 man hours per foot of track. At the end of a 2-week period, when wages are computed suppose the gang has actually put in 1,950 hr. (15 men times 10 hr. per day times 13 days), and that they have raised and completely surfaced 7 miles of track or 36,960 ft. The standard hours to be compared to the 1,950 actual hours are then 39,960 ft. times 0.055 man-hours per foot, or 2,031 standard hours; 2,031 divided by 1,950 gives an efficiency percentage of 104%. This pays a bonus of 24% on the wages of each individual in the gang for the pay period in question.

In this case some one may ask how is it possible to determine whether the workmanship is acceptable. Some one must pass upon the acceptability of all work done, whether on bonus or otherwise. We have standards of quality, whether written in specifications and drawn on tracings or simply implied and enforced by inspection. The laborers and gang have to be impressed that the work must be done according to the usual standards of quality. In rare instances trackmen have had to be impressed with this by causing them to lose their bonus or requiring that they do the work over without a bonus.

Carpenters on Bridge Work.—Foreman and 12 bridge carpenters assigned to build new deck and install deck on new bridge. Air compressor and pneumatic equipment for boring and tapping furnished.

To illustrate the method of computing wages, suppose that the foreman got $7 per day, that 13 bridge carpenters got $6 per

	Wages	Bonus	Total
Foreman	$91.00	$7.28	$98.28
Bridge carpenter	78.00	6.24	84.24
Man to dress tools	65.00	5.20	70.20
Man to tend compressor	52.00	4.16	56.16

day each, that one man received $5 per day to dress tools, etc., and that one man received $4 per day to tend the air compressor. Assume a standard of 2 days' time for each foot of finished

bridge deck and that at the end of a pay period of 13 working days they had completed 905 ft.

The actual days of labor were, say, 16 × 13, or 208; the standard days of labor were 905 ft. × 0.2, or 181; the efficiency was 87% (standard 181 divided by actual 208), which pays a bonus of 8% on wages.

Construct Concrete Arch Bridge.—Build a small concrete arch bridge for new line of railroad. (*a*) Dig foundations.

Suppose, on examination, here a standard is set of 0.25 of a man-day per yard of excavation. If six men and a foreman completed the job in 8 working days with a yardage of 230 yd., the computation for bonus payment would be as follows:

Seven men for 8 days, equals 56 actual days and 230 yd. times 0.25 man-days per yard equals 57.5 standard days. This gives an efficiency percentage of 103 (standard 57.5 divided by actual 56), which in turn entitles all hands to a bonus on their wages earned during the period, of 23%. Now, in practice this bonus percentage and the bonus in dollars is not computed for each job separately, but rather by pay periods, and to illustrate how different jobs are combined, we will suppose the gang mentioned above spends the remainder of the time in the pay period in unloading and storing sacked cement.

(*b*) Unload and store sacked cement. Suppose six men and foreman (same gang as above) worked 4 days and unloaded, trucked and stored 8 cars of cement, for which a standard had been set of 3 man-days per car. Their actual time is seven men for 4 days, equals 28 man-days and the standard is eight cars times 3 man-days per car, or 24 man-days. If the 84 days covered constituted a 2-week pay period, the wage and bonus earnings would be something like this:

	Standard days	Actual days	Efficiency, %
Job No. 1	57.5	56	..
Job No. 2	24	28	..
	——	—	—
Total	81.5	84	97

Bonus percentage for efficiency of 97% is 17% of wages; therefore the wages and bonus would be as follows:

	Bonus	Total
Foreman, \$5 per day for 12 days, or \$60	\$10.20	\$70.20
Six men, each \$4 per day for 12 days, or \$48	8.16	56.16

(c) Build forms (carpenters). Suppose carpenters now go to work on the forms.

To illustrate such a condition we will assume that the job was started at the beginning of a pay period and at the end of the period was not yet completed, but that 2,000 sq. ft. had been put in place, that the number of men engaged was four plus a foreman, and that the standard was 0.025 days per square feet. The actual man days were then five men for 12 days, or 60, and the standard was 2,000 sq. ft. times 0.025 man days per square foot, or 50 man-days. The efficiency on the job then was the standard of 50 divided by the actual 60 or 83%.

Standards Should Cover Small Gang Only.—It is most desirable to have the standards cover individuals only, where this can be done, separating the operations into parts. Although this makes more clerical work it is certain to stimulate the workmen to do their best. The next best plan is to have the standards separated so as to cover the work of small groups. If any drones are in the gang the others will raise a noise and ask to have them replaced if a bonus is involved.

It is not advisable to set standards covering the work of over 30 men in a gang. When more than that are included in one efficiency standard, the effect is lessened. In such cases it becomes something like a profit-sharing plan where all workers share alike in the annual profits. The possibilities in profit-sharing plans are too distant, too vague and not directly tied in with the work of any one individual, hence their effect is not very great.

Some suggested units of productions are as follows: In excavation, cubic yards removed; in railway construction, feet of track or number of ties or rails laid; in masonry, cubic yards in place; in building construction, if concrete, feet of floor laid; if steel, tons of lineal feet in place; if wood, square or cubic feet in place.

It is understood that this method entails more clerical work than is needed where straight hourly wages are paid. However, as by its means a reduction of 15 to 25% in labor cost is often attained, the extra cost of the clerical and other supervision is well expended. Contractors should bear in mind that this

has been proved to be an excellent means of increasing output per workman in many industries, and that at a time such as the present when greater production is essential to prosperity, every effort should be made to conduct thier operations more efficiently.

A Bonus System on the Yakima-Tieton Main Canal applied by E. C. Finley, engineer U. S. Reclamation Service, was described in *Engineering News-Record* as follows:

In order to assist in the solving of the problem of getting sufficient labor while weather conditions were favorable, a bonus system of wages was adopted. The work had been started in 1916 and continued in 1917, and the plans were to complete the job in 1918. There were 126 stations completed in 1916; 97 stations in 1917, and 254 stations remaining. There had always been a labor shortage on this work, but especially during 1917. In 1916 the average progress was 150 ft. per day; in 1917 this average was brought up to 160 ft. per day.

As is the practice in establishing a bonus rate, the cost is divided equally between the employer and employee for any amount of work done over and above what is considered an average day's work, amounting to about 3 cts. per man per foot. Laborers must have a certain amount of bonus in order to become interested, and it was decided that 140 ft. per day should be counted as a good day's work. Therefore, each man in the crew received 1½ cts. per foot each day for any amount completed over 140 ft. The granting of this bonus was contingent on a man working 10 days, and the amount of bonus was determined on each 10-day period.

During the first two bonus periods the average amount of work was about 200 ft. per day. During the third bonus period this average was brought up to 220 ft. per day. The interest in this system of paying for work seemed to grow from the beginning of the work, and during the last period, which was from Nov. 10 to the date of completion, Nov. 18, 1918, the average was 300 ft. per day, with a maximum of 404 ft.

Without a doubt, the result of this system of wages was very material in obtaining sufficient men to complete the work. This scarcity of labor was such that only three crews were working until Oct. 25, and four crews from this date until the completion of the work. There was an increase daily of the number of men in camp from 40 at the beginning of October to a maxi-

mum of 160, the increase being gradual. There was very little trouble in holding the men on the work, as wages in general were good and so was the mess.

Figuring the cost of the work done in 1918 carried out under the prevailing wages without bonus, using the work done in 1916 as a basis, it amounts to $3 per lineal foot, which was the estimate prepared for the work. The main result of the bonus system was that it proved to be a sound basis for productive efficiency. The entire canal was completed, and the figures show that the advance in costs in 1918 is considerably below the general advance in labor and materials.

The work was done under the supervision of R. K. Tiffany, project manager of the Yakima Project, with Mr. Finley as engineer in direct charge of the work.

Rapid Tunnel Driving under the Bonus System.—The salutary effect of payment by the bonus system is well illustrated by the results obtained in tunnel driving. In *Engineering News*, Aug. 26, 1915. J. R. McFarland gives the following data on driving the Mount Royal, Arizona Copper, St. Louis Water-Works and the Laramie Poudre, tunnels. The bonus system was used at all the tunnels mentioned, and is the only practice of note that was common to those five contracts. Different types of drills, some with and some without carriage mountings, both long and short rounds, and different methods of handling the muck were used.

The cost of tunnel driving is practically constant for each day's work, but the cost per foot varies with the rate of progress. From past performances the average advance per day, week and month is known, and it is expected that under normal conditions this rate of progress will be maintained. If exceeded, there is of course a considerable saving to the contractor; and where the bonus system is in force he pays his men a certain amount, as their just portion of the saving effected, for each linear foot of advance in excess of the base rate. The saving realized by the bonus system in the labor cost is shown in the tabulation which follows:

Labor Saving by Bonus System

	Per cent.
Mount Royal Tunnel	15
Arizona Copper Tunnel	20
St. Louis Water-Works Tunnel	50
Laramie Poudre Tunnel	31

The cost of driving the tunnels during the record months under the bonus system has been compared with the cost of driving before the bonus system was adopted. Before considering the several projects separately the accompanying tables should be examined. Table 3 gives some general data as to character of rock, size of heading, etc., while Table 4 shows the approximate number of men at work.

TABLE 3.—DATA OF TUNNELS WHOSE RECORDS ARE COMPARED

	Mount Royal tunnel	Arizona Copper tunnel	St. Louis Water-Works tunnel	Laramie Poudre tunnel
Rock	Trento limestone with igneous dikes	Granite porphyry; good drilling	Both hard and soft limestone	Moderately hard, gray or red granite
Size of tunnel heading	8×12 ft.	8×8 ft.	8 ft. diameter (circular)	7½×9½ ft. (elliptical)
Average cross-section	3.56 cu. yd. per foot advance	70.04 sq. ft.	95 sq. ft.	62 sq. ft.
Record advance in 31 days	810 ft.	799 ft.	745 ft.	653 ft.

TABLE 4.—TOTAL LABOR ON TUNNEL CONSTRUCTION

	Mount Royal tunnel	Arizona Copper tunnel	St. Louis Water-Works tunnel	Laramie Poudre tunnel
Superintendents	2	..	1	1
Foremen or bosses	3	1	3	3
Drillers and helpers	24	12	24	15
Muckers	24	15	22	18
Miscellaneous labor of all classes	59	12	51	22

The bonus paid to the men at the Mount Royal tunnel was 7% of their daily pay for every foot over 14 ft. per day. The influence of the bonus system on the work at this tunnel is shown by Table 5.

TABLE 5.—MOUNT ROYAL TUNNEL

Costs	A typical month without bonus	Record month with bonus
Labor	$9,989.00	$15,883.00
Equipment and supplies	2,927.00	4,750.00
Total, including overhead	13,916.00	21,633.00
Advance, at 14 ft. per day	434.00	810.00
Per foot (labor)	$23.00	$19.61
Per foot (labor, equipment and supplies)	29.76	25.47
Per foot (total)	32.06	26.70
Per cubic yard (labor)	6.48	5.51
Per cubic yard (total)	9.00	7.51
Saving (in labor) in cost per foot, by bonus system	....	3.39
Saving (in labor, equipment and supplies) per foot	....	4.29
Saving (total) per foot	....	5.36
Saving in total cost per cubic yard	....	1.50

At the Arizona Copper tunnel the men received regular wages, and for every foot of advance over 350 ft. per month a bonus of $7 was divided. This was only a trial, but although it was found that the bonus was excessive, it was not reduced, as the duration of the test was short. The tunnel was driven the first month without a bonus and the three succeeding months with a bonus. A comparison of the advances and the costs per foot of tunnel in each case is shown by the figures in Table 6.

Three shifts per day were employed at the St. Louis Water-Works tunnel. A minimum advance of 72 ft. per week was set, and for all over that amount the following bonus rates were paid: Superintendent, 50 cts. per foot; heading foreman, 50 cts.; muck foreman, 30 cts.; drill runners, 30 cts.; drill helpers, 20 cts.; nipper, 20 cts.; muckers and cage men, 10 cts. Each shift was credited with one-third of the extra progress and received one-third of the bonus.

Three shifts per day were employed on the Laramie Poudre tunnel. For the first part of the work each under-ground workman was paid a bonus of 25 cts. per day for each 25 ft. in excess of 400 ft. per month. This system was soon discontinued, as it was found to be not only cumbersome but excessively high, and the following system was adopted: When the rate of driving

TABLE 6.—ARIZONA COPPER TUNNEL

Costs	Without bonus first month	With bonus Second month	Third month	Fourth month
Labor	$3,773.00	$5,314.24	$5,802.69	$6,574.77
Equipment and supplies	2,013.33	2,013.33	2,013.33	2,013.33
Labor, equipment and supplies	5,786.33	7,327.57	7,816.02	8,588.10
Advance in feet	350	582	664	762
Per foot (labor)	$10.78	$9.13	$8.74	$8.63
Per foot (labor, equipment and supplies)	16.53	12.59	11.77	11.27
Cubic yards of rock removed, labor, equipment and supplies	6.33	4.82	4.51	4.32
Saving on labor, per foot, by bonus system	....	$1.65	$2.04	$2.15
Saving on labor, equipment and supplies, per foot	....	3.94	4.76	5.26
Saving on labor, equipment and supplies, per cubic yard	....	1.51	1.82	2.01

for any calendar month exceeded 400 ft. and was less than 500 ft., each underground employee was paid $10 extra; between 500 and 600 ft. the bonus was $15, and between 600 and 700 ft. it was $20. In order to distinguish the bonus money from the regular wages the bonus was paid by check. The itemized account is given in Table 7.

TABLE 7.—ST. LOUIS WATER-WORKS TUNNEL

Costs	Estimated without bonus	Cost per day with bonus
Labor	$381.75	$381.75
Total bonus per day	....	66.80
Advance, feet per week	72	745
Labor per foot	$37.09	$18.66
Labor per cubic yard rock removed	10.54	5.30
Saving in labor, per foot, by bonus	.....	18.43
Saving in labor, per cubic yard, by bonus	.....	5.24

TABLE 8.—LARAMIE POUDRE TUNNEL

Items	Estimated without bonus	Cost per day with bonus
Straight wages	$242.65	$242.65
Total bonus per day	......	29.68
Advance per month in feet	400	653
Labor, per foot	$18.76	$12.94
Labor per cubic yard removed	8.16	5.60
Saving per foot due to bonus	....	5.82
Saving per cubic yard due to bonus	....	2.56

Rules for Determining Bonus Payment on the Los Angeles Aqueduct.—The Los Angeles Aqueduct, some 217 miles long, was constructed nearly entirely by force account work. One of the features of the management, the extensive use of a bonus system of payment of labor, proved to be very successful in hastening construction and reducing costs. In *Mines and Minerals* for June, 1912, the rules adopted by the engineers in charge of the work to govern bonus payments are given as follows:

1. *Length of Period and Time of Measurements.*—Ten days shall constitute a period. The first period to be from the first to the tenth, of the month, inclusive; the second from the eleventh, to the twentieth, inclusive; the third from the twenty-first to the end of the month. Bonus payments shall be allowed upon the basis of measurements made at the close of each 10-day period.

2. *Employes Entitled to Bonus.*—The following named classes of employes shall be allowed to participate in bonus payments: Tunnel foremen, when in charge of more than one bonus crew; shift bosses, miners, muckers.

3. *Tunnel Foreman.*—The tunnel foreman shall not be considered as one of the "shift crew." If he is in charge of more than one bonus crew he shall be allowed bonus based upon the "mean" bonus progress per shift of all bonus crews under his supervision.

4. *Shift Boss.*—The shift boss shall be considered as one of the shift crew. He will participate in the bonus on the same basis as the men of the crew under his direction. An exception to this

rule is made when a shift boss is placed in charge of two or more shifts in different headings. In this case he would be placed on the same basis as a foreman, towit, not be considered as one of the crew, and would be allowed bonus based upon the mean bonus progress.

5. *Number of Shifts Allowed.*—The number of shifts worked in a heading during a day of 24 hr. shall be determined by the engineer or superintendent in charge of the work after consultation with the chief engineer.

6. *Trimming and Timbering.*—All trimming must be done by the crew sharing the bonus. If the timbers are placed by the miners from the standard crew in a given 10-day period, then that portion of the tunnel shall be considered as a timbered section; otherwise it shall not be so considered.

7. *Continuous Work and Exceptions.*—Only men who work continuously through the 10-day period—with the following exceptions—shall be entitled to the bonus:

(*a*) Any employe, entitled to bonus earnings, who is injured or becomes ill during a period from conditions arising directly from tunnel construction, shall participate in bonus in proportion to the number of shifts worked by him during said period.

(*b*) If an employe, entitled to bonus earnings, is transferred during a period from a heading to another part of the work for reasons other than his own request, he shall participate in bonus in proportion to the number of shifts worked by him on such heading.

8. *Interruptions of Work.*—If the work is interrupted by the failure of power, shortage of material or supplies, floods, cave-ins, or other causes beyond the control of the men, the men shall be entitled to bonus pay in proportion to the number of shifts worked by them during period in which such interruptions occurred.

9. *When Both Timbered and Untimbered Work is Done by the Crew in the Same Period.*—To establish a uniform system of computing bonus earnings in above case the following formula will be used:

FORMULA.—

$$\frac{x+y}{\frac{x}{a}+\frac{y}{b}} = \text{average base rate per shift.}$$

EXAMPLE.—

Let x = timbered progress = 25.0 ft.;
y = untimbered progress = 30.0 ft.;
a = required timbered per shift = 2.0 ft.;
b = required untimbered per shift = 2.5 ft.;
s = number of shifts during period = 20.0

Then

$$\frac{x}{a} = \text{shifts required at base rate;}$$

$$\frac{y}{b} = \text{shifts required at base rate.}$$

Or, substituting values,

$$\frac{25}{2} = 12.5 \text{ shifts required at base rate}$$

$$\frac{30}{2.5} = 12.0 \text{ shifts required at base rate}$$

Total, 24.5 shifts required at base rate

$$\frac{25 + 30}{24.5} = 2.245 \text{ average base rate.}$$

$20 \times 2.245 = 44.9$ ft. = progress required.
$55 - 44.9 = 10.1$ ft. = bonus footage.

10. *Computations of Bonus Footage and Earnings.*—The computations of bonus footage shall be made by dividing the total number of feet run during the period by the total number of shifts worked during the period. From this average footage per shift there shall be deducted the base rate of progress required, and the remainder, if any, will be the bonus footage per shift. The bonus earned *per man* during the period, will be the number of shifts in which he worked, times the average bonus footage, times the bonus price per foot. (Provided all conditions as outlined in these rules are complied with.)

EXAMPLE 1.—Three shifts working 10 days.
Total progress for period, 150 ft.
3 shifts × 10 days = 30 shifts worked
150 feet ÷ 30 shifts = 5 ft. per shift
Base rate of progress = 3.5 ft. per shift

Bonus footage 1.5 ft. per shift.

Bonus earned for period *per man* = 1.5 ft. × 10 shifts × 25 cts. per foot = $3.75.

EXAMPLE 2.—One shift working 10 days.
Total progress for period 50 ft.
1 shift × 10 days = 10 shifts worked
50 feet ÷ 10 shifts = 5 ft. per shift
Base rate of progress = 3.5 ft. per shift

Bonus footage 1.5 ft. per shift

Bonus earned for period *per man* = 1.5 ft. × 10 shifts × 25 cts. per foot = $3.75.

11. *Interpretation of Rules.*—If any of the above rules are not clear to the engineers or superintendents in charge of work, such rule must be referred to the chief engineer for interpretation.

12. The chief engineer shall determine what tunnels shall be given certain base rates and bonus per foot as outlined in the schedules for the various divisions.

The base rate for determining the bonus depended on whether the rock was soft or hard, or whether the excavation was timbered or untimbered; on the number of men on each shift advancing the work; whether the work was done by machine drills or hand drills, and finally on the square feet of cross-section for the tunnel. Bonus schedules were prepared and approved for tunnel driving on the Little Lake division, Bowlder Peak and Grapevine sections of Division 5-A; the Jawbone division; the North Antelope division; the Elizabeth tunnel and the Saugus division. As the Los Angeles Aqueduct is 217 miles long it follows that there were different kinds of rock which varied in hardness, consequently the bonus footage varied. Two schedules, one for the Jawbone division and the other for the Saugus division of the tunnel are here given.

TABLE 9.—BONUS SCHEDULE FOR TUNNEL WORK IN THE JAWBONE DIVISION

Capacity of tunnel, second-feet	Class of rock	Timbered or untimbered	Class of work	Base rate per shift, feet	Number of men per shift	Bonus per man per foot per shift, cents
430	Soft	Untimbered	Hand	4.0	9	25
430	Soft	Timbered	Hand	4.0	9	25
430	Hard	Untimbered	Hand	2.5	10	25
430	Hard	Timbered	Hand	2.0	10	25
430	Hard	Untimbered	Machine	3.0	11	40
430	Hard	Timbered	Machine	2.3	11	40

TABLE 10.—BONUS SCHEDULE FOR TUNNEL WORK IN THE SAUGUS DIVISION

Capacity of tunnel, second-feet	Class of rock	Timbered or untimbered	Class of work	Base rate per shift, feet	Number of men per shift	Bonus per man per foot per shift, cents
1,000	Hard	Untimbered	Hand	2.3	13	40
1,000	Hard	Timbered	Hand	2.0	15	40
1,000	Hard	Untimbered	Machine	3.0	15	40
1,000	Hard	Timbered	Machine	2.5	17	40
1,000	Soft	Untimbered	Hand	3.0	13	35
1,000	Soft	Timbered	Hand	2.5	15	35
420	Soft	Untimbered	Hand	4.0	11	25
420	Soft	Timbered	Hand	3.5	11	25
420	Soft	Untimbered	Machine	5.0	11	25
420	Soft	Timbered	Machine	4.5	11	25

Bonus for Laborers (Increases Yardage and Lowers Cost of Paving).—In *Engineering News-Record* April 11, 1918, Clarence E. Ridley describes how, in the face of severe labor shortage, paving work was speeded up by paying a premium to every man in the gang, as follows:

Costs per square yard of paving were reduced from 21 to 12 cts., yardage was increased from 3,390 to 5,485 sq. yd. in a 2-weeks period, and labor turnover was reduced by the City of Flint, Mich., which is constructing by day labor approximately ten miles of pavements and thirty miles of sewers this season. The city had experienced a great deal of labor difficulty. The chief industry of Flint is the manufacturing of automobiles, which has made heavy inroads on the supply of skilled labor. Extensive building contracts under way have further increased the labor shortage.

The particular crew in question had been a problem all season. Foremen had been changed four times, and the entire personnel of the crew at least as many times. Changing foremen and laborers and giving a bonus only to foremen were all to no avail, the cost remaining above the estimate and the quantity of work done fast falling below the schedule.

This contingency led the writer to figure out a bonus system, whereby every man on the job would share according to the amount of work done. The proposition was made to the men that each man on the job should receive a bonus of one cent per square yard in excess of his regular wages for all over 500 sq. yd. of 6-in. foundation placed in a 10-hr. day. The gang was limited

to 12 men, exclusive of the foreman. Previous to this as many as 16 men were allowed. The gang was composed of a foreman at \$4.17 per day, an engineer at \$4, a fireman at \$3.33, a cement carrier at \$3.75, three concrete men at \$3.50 and six shovelers and wheelers at \$3.50 each.

At the above wages and allowing to each man the 1-ct. bonus per square yard for all over 500 yd., the unit costs would vary as follows: 300 yd., 15.6; 400 yd., 11.7; 500 yd., 9.4; 600 yd., 10.0; 700 yd., 10.4; 800 yd., 10.7; 900 yd., 11.0; 1,000 yd., 11.2.

As seen in the foregoing, approximately 500 sq. yd. per day would give the minimum cost, but where the overhead expense is considered, to say nothing of the desirability of getting through a job with as little inconvenience as possible to traffic is taken into account, almost everybody would be unanimous for the 1000 sq. yd. per day, with only a difference of 1.8 ct. per square yard.

Now as to the practical side of the method. The pay-roll of this particular gang referred to, previous to the time of trying the bonus method, amounted to \$708.68 for a 2-weeks period, during which time they placed 3,390 sq. yd. of 6-in. 1 : 6 concrete foundation on pavements varying from 21 to 24 ft. in width. The average for the 12 days was 283 sq. yd. per day at a cost of nearly 21 cts. per square yard.

The next payroll of the gang on the same kind of work, including the bonus, amounted to \$646.45. In the same period of time they deposited 5,485 sq. yd. at an average cost of less than 12 cts. per square yard. During the first period the weather was such that no delay was necessary, while during the second period rain interfered with the work on 6 different days and on 2 days they were unable to operate at all. In spite of this handicap the gang averaged 548½ sq. yd. a day. One day with weather permitting them to run only 9 hr. they placed 882 sq. yd. The result was an increase of 62% in yardage and a decrease in cost of 43%, compared with the previous 2-weeks' period.

Bonus Plans for Motor Truck Operators.—*Engineering and Contracting*, August 20, 1919, gives an article by Harold P. Gould, Chairman Truck Owners Conference, Inc., Chicago, reprinted from an issue of the *100% Magazine*, as follows:

The Economy Bonus.—The summary of the Economy Bonus Plans includes plans for the following purposes:

(*a*) Lowering Per Mile Cost.

(*b*) Increasing Tire Mileage.

(*c*) Decreasing Spring Breakage.
(*d*) Decreasing Accidents.
(*c*) Increasing Gasoline Mileage.
(*f*) Good Behavior.
(*g*) Regular Attendance.
(*h*) Not Getting Stuck on the Road.
(*i*) Keeping Car Out of Repair Shop.
(*j*) Reducing Customer Complaints.

Lowering per Mile Costs.—Ward & Ward, Inc., of Buffalo, have worked out a very successful bonus plan based on the cost of operation per mile. With the allowed cost at 7 cts. a mile, they give the driver all the saving he can effect on this standard and deduct from his bonus the cost of all accidents unless proved to be outside his control.

Production remains at a predetermined standard because the deliveries are made to customers on fixed routes, under very nearly standard conditions of roads and loads; time does not enter in, because if the driver takes longer than he should he is simply running his day longer without cost to the company. The deduction for accidents has been carefully made under Mr. Ward's personal supervision.

First of all, a fair wage is paid; the man starts at $20 a week, the next month receives $22 a week and the sixth month $24.

In figuring cost per mile on 1½-ton trucks, garage cost, depreciation and insurance were not included and it came to gas, oil and tires.

Bonus payments are made every four months. Three drivers earned at the last distribution $75, $50 and $30, respectively; three times that sum for 12 months is a very respectable bonus earning.

Better satisfied drivers, more careful with their trucks, and working for the interest of the company, as well as lower maintenance cost on the cars were the good results of the use of this bonus plan. Three cars were run nearly 1,000 miles a month for 11 months each and were laid up only a total of 5 days for repairs.

Four Combined Bonuses.—The Gilman Trucking Co. of Cleveland offers its drivers four simple bonus payments of $5 each for accomplishing four different results, as follows:

1. For regular attendance and no absence without excuse previously granted by the foreman.

2. For good behavior.

3. For not getting stuck on the road.
4. For keeping the truck out of the shop in working hours.

This made it possible for each driver to earn $20 per month for exercising proper care, and resulted in lower cost and greater production to the company.

Spring and Tire Bonus.—McCrady Brothers, in the coal and building material business in Pittsburgh, are operating two simple bonus plans with excellent results, the first on tires and the second on springs.

Each driver is offered $1 for each 1,000 miles he runs his truck over the maker's guaranteed 7,000, and $2 for each 1,000 miles he runs his duals, or large single tires on the rear wheels, over the maker's guarantee.

When a driver runs his tires 14,000 miles, for instance, he earns $7 bonus on each front wheel and $14 for each rear wheel, a total of $42 bonus.

As it costs the company from $12 to $22 per 1,000 miles for one of these tires, for the first 7,000 miles, the extra dollar or two paid in bonus is earning from 10 to 12 times its cost to the company.

The good results are not only satisfied drivers and increased mileage on tires, for when the rear tires are so handled as to run more miles, it stands to reason that the differential will run more miles and the engine will run further without an overhaul. Careful driving means longer wear on every part of the machine.

A 10% overload is all that is allowed on these trucks and the drivers have no desire to put on more load or to speed the trucks because it is working to their detriment in the tire bonus.

One driver that earned a bonus for running his front tires 7,000 miles over the guaranteed distance, hauled 770 tons more in a 3 months' contest than another driver with a lower tire mileage in the same time, proving that the economy bonus on tires did not lessen the production of the truck.

When William McCrady offered his drivers a $3 bonus for every month in which no springs were broken, he did it to meet a serious situation, for on one truck they were averaging two broken springs a month at a cost of $20 each, or $40. Immediately after this bonus was offered the worst truck in the fleet ran 2 months without a broken spring.

Again, there was reflected a benefit to the rest of the truck, because the breaking of the spring means the breaking of other parts at the same time. The more careful driving to earn the

spring bonus pays hundreds of dollars each year on a machine in lessened repair bills on other parts of the truck.

Joseph Horne Co. of Pittsburgh, whose department store fleet has received effective administrative attention from F. C. Schatz, has developed several effective economy bonus plans.

The first bonus is an efficiency bonus, figured by crediting for good conduct and good mileage and debiting the driver for failures and complaints registered by customers with the complaint department.

The second bonus is given for the care of the car. No repairs are made without the authorization of Defect Cards, initialed by the drivers, so that this item as affecting their earnings can be kept in the control of the driver to a certain extent.

The third bonus is for economy in tire cost, or, in other words, for high tire mileage.

The fourth bonus is the half-yearly no-accident bonus. The driver forfeits his whole bonus if he has an accident within the 6 months' period, with one exception; he is not responsible if his car, left standing empty at the curb, is hit by another vehicle.

These four bonus plans in conjunction have been very successful in rewarding the better operators, causing the poorer men to strive for better records and the consequent better earning.

Wilson & Co. of Chicago have recently inaugurated a plan of giving prizes for tire economy. They give the driver 30% of the "gravy" on sets of tires or single tires for number of miles run over 10,000, guarding against damage to the rims by the regulation that tires must be changed when worn down to within ¾ in. of the steel base.

Pooled No-accident Bonus.—Tiffany Studios of New York have a simple pooled no-accident bonus for the drivers and helpers on their trucks. They feel that alertness and watchfulness on the part of the helpers will tend in great measure to prevent accidents, so they are allowed the same bonus as the drivers.

Each man is allowed a bonus at the rate of $10 a month, payable twice a year, or $60 every 6 months.

It is understood that if an accident occurs through carelessness on the part of any of the drivers or helpers, its cost will be deducted from the bonus fund, so that all of the drivers and helpers will be affected. This makes all of them take an interest in preventing accidents, not only to themselves, but to each other.

The company carries insurance protecting it against dam-

age to other cars, but they have so few accidents that they have dropped the insurance covering their own trucks and by carrying it themselves, are ahead on the deal.

They have had so few accidents which their insurance has not adequately covered that they have not as yet made any deductions from the bonus account, so that the men have always received their $10 per month in full.

If any man leaves their employ he forfeits his interest in the unpaid bonus fund, and it is distributed among the remaining men. This helps to keep the men satisfied with their positions and to hold them on the job.

The Miller North Broad Storage Co. of Philadelphia operated a similar no-accident bonus plan for three months during the dullest part of their season.

This was an unfortunate time to test it out, by reason of the fact that they were unable at all times to make up the expenses incurred through accidents as promptly as they should have done in a busier season, and it tended to throw discredit upon the bonus.

At the end of three months, when they expected to get the greatest benefit from the plan, conditions compelled them to make a substantial raise in the wage of the men, and because of certain weaknesses in the bonus plan, they felt it prudent at the time to abandon it.

Paper-credit Bonus.—Parke, Davis & Co. of Detroit have a simple economy bonus in use for the drivers of their eight city delivery trucks. Each month that a driver has no accident, whether his own or another driver's fault—and the loss of the smallest piece of equipment is put in the category of accidents—he receives a $5 paper-credit bonus, payable in cash on the first of May of each year.

For the least or the greatest accident in a month a driver forfeits his entire $5 credit. A nightly inspection of the cars at their garage carefully checks up the condition of the machines and their equipment.

The excellent effect of this plan may be seen from a study of the May, 1919, distribution: Four drivers received the full amount of $60, one man received $50, and three $55. One driver with one accident charged against him delivers in the thick of traffic all the year round.

This is the more remarkable when the comprehensiveness of the conditions covered by the bonus is remembered. The

four perfect records mean that four cars had suffered no damage whatever from accident, and that they had lost not so much as wrench during the year's service.

The Jacob Van Skiver Co. of Philadelphia have a bonus, or demerit system, for reducing maintenance cost on their fleet of trucks. They pay their drivers $30 a week if they keep the trucks on the road, but if for any reason a truck is kept in the garage, the driver is penalized $1, or has his pay reduced from $5 to $4 per day until his truck is out again. He may be sent out on another truck if he is not needed to repair his own truck, but must stand the cut in salary just the same.

Whereas the drivers in the past often found something the matter with their cars in bad weather to keep them in the garage, they changed their minds and decided that they would rather drive outside than pay a dollar for the privilege of staying in.

The Credit System for Economy.—The Chicago Motor Bus Co. uses its debit and credit system as a pooled bonus plan to increase gasoline mileage, in one month paying out $300 in increased salaries to secure a saving of $1,200 in gasoline, and in another case paying all the employes from a pooled monthly bonus for the reduction of accidents on a mileage basis.

The Service Bonus (*B*4).—Service bonuses can hardly be classified with production and economy, or combined bonus plans and credit systems, although they have a definite effect in reducing the labor turnover and in making drivers satisfied with their jobs.

John Wanamaker has a simple bonus plan of giving the drivers $50 for every year of continuous service, and helpers $35 for a year of continuous service, in addition to the regular profit-sharing and welfare provisions made for all the employes of the Wanamaker organization.

Strawbridge & Clothier of Philadelphia, another large retail store, has a yearly bonus plan for drivers and helpers.

The Fair, Chicago, offers a 2 weeks' vacation with full pay after a full year's service, in addition to a Christmas bonus of $75 after 1 year's service, $40 after 6 months' service, and $25 after 3 months' service.

The Crane Co., as is well known, gives every employe a Christmas present of 10% of his yearly wages, which, at the customary wage of truck drivers, would amount to approximately $150 a year.

This plan is criticized by many as being nothing more than

a deferred salary payment, since the 10% bonus is counted on by all the employes when considering whether or not they will leave the company for higher immediate salary somewhere else. It certainly has nothing to do with the productivity of the faithful performance of scheduled duties by the employes individually.

Yearly Bonus with Saving Feature.—The Walter J. Crowder Co. of Philadelphia has met its labor problem by a systematic campaign to cooperate with their drivers. They formed an employes' organization to promote good fellowship and interest in the company, and instituted a simple bonus plan.

Each of the drivers pays 50 cts. a month in dues and the company puts 50 cts. with it for a Christmas saving fund; then, just before Christmas, each man receives a check for $12 from the company.

Systematic Raise in Wages.—The Erie Service Co. of Buffalo finds that a scheduled raise in wages keeps the drivers satisfied and works out well for the company.

They start a driver out at $20 a week, at the end of each month give him a raise of $1 per week until in 6 months' time his wage is $26 a week. In addition they pay 40 cts. an hour for overtime. The assured increase each month tends to keep the drivers satisfied until they are getting the maximum; from then on they stick to keep up that maximum income.

Basis for Bonuses Must Vary with Conditions.—It is easy to vary the basis of the bonus plans to suit the conditions in any particular business. If a business, for instance, is delivering to a large number of customers on long routes, it would be foolish to try to pay a bonus on the ton-mile basis, because the ton-mileage in that case would be very difficult to obtain and not worth the trouble. Per package delivered and the tons delivered in the total trip, number of calls made, or some other such basis should be used in such a case.

The Pooled Bonus.—Pooled bonuses have been very successful in certain factories where they have been tried, because as high as 700 operatives in a single department or plant can be placed upon a pooled or combined bonus that rewards every employe in the group for production records or economies of that group.

During the war the Goodrich Tire & Rubber Co. had as high as 700 employes in the balloon department, sharing a pooled bonus on the following basis: Every piece of work pro-

duced was credited to the bonus account at a pre-determined piece-rate price. The wages for the workers were deducted in total from this fund and the balance distributed among the workers, all 700 of them, in proportion to their wages.

There are many cases where truck operators cannot in fairness accept a certain bonus standard and reward for their different drivers without working injustice upon the men who have the harder route or the more expensive runs for low production. The heavy and expensive run may be the run of lower production also through the exigencies of the business.

In this case a pooled bonus is suggested that credits all the drivers in a pool with the earnings of the fleet as a whole over previous earnings or earnings agreed upon as standard and, after the wages are deducted, leaves a bonus fund to be divided among the men according to the wages earned. The men will see to it in this kind of an arrangement that no one of the men reduces the profits of the others in the group by his laziness or poor methods.

The pool method has been used successfully by the Chicago Motor Bus Co. under the credit system, both in the machine repair shop and in the gasoline economy bonus.

Similar results are shown by the Tiffany Studios in their no-accident bonus.

While not having all the advantages of a bonus set upon individual records and paid to the drivers in proportion to their merit as in the Timken plan, the pooled bonus has other advantages not possessed by the individual bonus, because of the close supervision of the poorer workers by the better workers, which the individual system does not so much inspire. It is very much easier in many cases to install the pooled bonus.

Objections to Production and Economy Bonuses.—H. H. Ball of the Molstedt Lumber & Coal Co., New Rochelle, N. Y., stated that his company put in a bonus plan some time ago based on the number of tons of coal that his driver could deliver.

Not having a proper check or allowance for extra damage to the equipment, he found that it was only a short time before he had to take the extra help he saved in the production end, and put them in the repair department. He thinks that the result was just simply human nature on the part of the drivers, who got paid to produce without being penalized for causing extra repairing.

Fixing Standards for Incentive Wage Plan.—Most incentive wage plans are based upon the time required to complete a job.

The selection of the fair time, or as it is sometimes called the "standard time," required for an operation involves the making of time studies and careful analyses. Proper rest allowances are made and the logical time allowances for each sub-operation are determined. After these steps have been taken, it is always desirable to classify these figures into a table which may be readily used by a clerk in specifying the correct standard time allowance on current jobs. This problem of the proper classification of basic standard time allowances is a real question with the industrial engineer and is worthy of special discussion. The method of procedure in such a contingency is explained by A. G. Bryant, Manager Betterment Department, Joseph T. Ryerson & Son, in the *100% Magazine*, by means of the following simple example:

In unloading lumber from a box car one or more boards at a time are drawn from the pile by a workman, dragged or skidded through the car door, to be piled on the outside by another man.

We will consider only the handling of the common sizes of southern pine. Let us assume that time studies have been taken with a sufficient number of observations on various sizes of lumber.

As a deduction from these time studies basic standard times have been selected for each individual size. The following are the sizes with the standard time required for each:

1 in. × 4 in. × 16 ft. 0 in.—0.38 min.
1 in. × 6 in. × 16 ft. 0 in.—0.40 min.
1 in. × 8 in. × 16 ft. 0 in.—0.45 min.
1 in. × 10 in. × 16 ft. 0 in.—0.47 min.
1 in. × 12 in. × 16 ft. 0 in.—0.48 min.
2 in. × 4 in. × 16 ft. 0 in.—0.42 min.
2 in. × 6 in. × 16 ft. 0 in.—0.44 min.
2 in. × 8 in. × 16 ft. 0 in.—0.46 min.
2 in. × 10 in. × 16 ft. 0 in.—0.48 min.
2 in. × 12 in. × 16 ft. 0 in.—0.50 min.

The next step is to consider what are the controlling factors, or in other words, the variables.

The weight of the board, of course, affects the amount of energy required to handle it and accordingly varies the time. Likewise the relative limberness of the lumber is a controlling factor.

When a thin board bends so that it is clumsy to handle it may require more time and energy than one which, though heavier, is stiffer.

In order to determine the effect of these factors, the standard times are plotted on the accompanying chart (Fig. 1). Each cross represents the time required to handle one size of board as shown in the foregoing table. The points are located according to a horizontal scale representing the weight of the lumber and a vertical scale representing time in minutes.

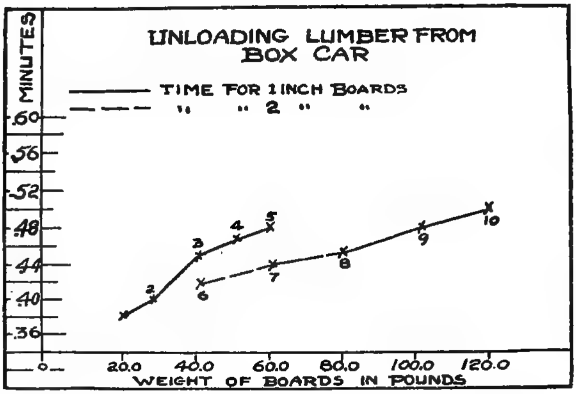


FIG. 1.—Chart showing standard times of handling lumber.

A solid line connects the crosses indicating 1-in. boards and a dash line represents the curve of the time for handling 2-in. planks.

A cursory glance alone tells the story of the difficulty in handling thin lumber. It will be noticed that heavier material actually requires less time than lighter, flexible, lumber.

It is not desirable to have a separate basic standard for each size of lumber and the question now arises as to the method to be followed in classifying.

Although we have no intention of setting up an arbitrary rule, good practice would seem to indicate that the exact standard time as predetermined for any size should not vary more than arranged to cover it.

Reviewing our chart, therefore, we see that points 1 and 2 may be classed together but that point 3 cannot be thrown in with them as there is a difference between 2 and 3 of 0.05 minutes or 12.5 per cent. We perceive, however, that points 3, 4 and 5 have a maximum difference of only 0.03 minutes or about 7 per cent. and can be grouped together.

Similar reasoning directs us to classify points 6, 7 and 8 and 9 and 10.

We have therefore derived four classifications and by averaging the standards in each one, we secure the time to cover the group for practical application.

Efficiency Wage Scale According to *Engineering and Contracting*, May 15, 1918.—A rating scale was adopted as the basis for wages at one of the large maintenance warehouses of the Los Angeles County Road Department at the time when a wage increase went into effect.

Previous to the allowance of the increase, all common laborers were paid $2.50 per 8-hr. day, regardless of ability. This flat rate prevented promotion within this class and removed one of the best incentives for efficient effort.

Many of the men had worked in the various paving, maintenance or bridge gangs under several foremen, so the value of each point in the percentage column was explained at a meeting of the foremen, and as the list of employes was read each foreman noted his value of the laborer. These figures were used to prepare a bulletin which fixed the rate of pay for the week following.

An immediate improvement was noted and the men were also pleased with the fairness of the system and the prompt weeding out of the few drones. A sample bulletin, using fictitious names, is given below:

Efficiency Bulletin

Under 70 % means dismissal.
70 % and over, $2.50 per 8-hr. day.
80 % and over, 2.75 per 8-hr. day.
90 % and over, 3.00 per 8-hr. day.

Name	Week beginning Nov., 1917			
	5th.	12th.	19th.	26th.
Aiken, Geo, L.	85	85	87	89
Amlin, John L.	85	87	87	87
Anderson, Ben	80	83	83	85
Avery, Russell	77	72	65	*
Beck, Frank A.	72	78	80	83
Brown, Clarence	93	93	93	95
Bryant, Jesse R.	85	80	80	77
Buell, Wm. N.	79	80	85	83
Buford, Chas. C.	82	77	68	*

*Discharged.

CHAPTER IV

MEASURING THE OUTPUT OF WORKMEN

Difficulties of Measurement.—Before men can be paid according to their performance it obviously is necessary to devise methods of measuring the number of units of work done, but it is not always so obvious what units to select nor how to measure them readily after the selection of units has been made. Indeed, this difficulty accounts in large part for the slowness with which piece rate and bonus systems have been adopted.

Subdivision of Units into Other Units.—In engineering construction the cubic yard is a very common unit upon which contract prices are based, but the cubic yard itself is frequently a very uncertain unit of performance, for it is a composite of other units. Thus, in rock excavation there are several distinct operations involved, which may be enumerated as follows:

1. Drilling.
2. Charging and firing (or blasting).
3. Breaking large chunks to suitable sizes.
4. Loading into cars, carts, skips, or the like.
5. Transporting.
6. Dumping.

The important item of drilling depends largely upon the spacing of the drill holes, which varies in different kinds of rock, and in different kinds of excavation, trenches and tunnels requiring close spacing. Clearly, then, the lineal foot of drill hole is a unit of work that must be adopted by the rock contractor in measuring the output of his drillers, and not the cubic yard.

Transportation is largely a function of distance, hence the unit of transportation cost should be the ton (or yard) carried 100 ft. or 1 mile, and not the cubic yard without the factor of distance.

Our first rule to be applied in seeking units that truly express the amount of work done is as follows: *Divide the contract price units into sub-units, selecting the "foot-pound" of work as the sub-unit wherever possible.*

A foot-pound is the unit of work used in theoretical and applied mechanics. It is the amount of work required to lift 1

lb. a height of 1 ft. All forms of work are capable theoretically of being expressed in foot-pounds, but it is often very difficult to do so in practice. For example, it is not an easy matter to ascertain how many foot-pounds of work a man performs in shoveling earth into a wagon, for there is not only the number of foot-pounds involved in lifting the earth but in pushing the shovel into the earth, in lifting the shovel, in lifting the upper part of his own body, and in overcoming the inertia of earth, shovel and body. However, the theoretical ideal unit is the foot-pound, and, in selecting the actual unit to be used, the effort should be made to secure a unit that is as closely proportional to the foot-pound as possible. Thus, in drilling, there are certain units of work done by the drill in pulverizing the rock in the drill hole, and this work is quite closely represented by the number of lineal feet of drill hole in any given kind of rock. Hence the most practical unit of work in drilling is the foot of hole drilled.

The second point to consider in selecting suitable units of work is the different processes involved. Each process on field contract work usually involves a different class of men. In rock excavation the six items above given usually involve six separate gangs of men. Although all contribute their part to the final contract unit upon which payment is received—the cubic yard—yet the work of each may be, and usually is, better measured in terms of some other unit. We already have seen that the lineal foot of drill hole—and not the cubic yard—is the unit to select for the drilling gang. The pound of explosive charged in the drill holes is a good unit by which to measure the work done by the blasting gang. The cubic yard of rock usually is the only practical unit of breaking large rock chunks. So, too, the cubic yard becomes the unit for loading and for dumping, whereas the yard-mile, or ton-mile, is made the unit of transportation. Still further subdivisions of some of these six processes are often desirable, yielding still other units that more closely approximate the foot-pound unit.

Therefore, our second rule is as follows: *Since construction usually is divided into processes, and since a separate gang usually performs each process, select sub-units based upon the work done by each gang.*

In order to apply this rule it frequently is necessary to reorganize the work so that each process is performed by its special gang. Where the work is not of sufficient magnitude to keep

distinct gangs busy on each separate process, it is still often possible it to work the same gang a few hours at one process and then shift to another process, instead of working the same men in a heterogeneous fashion on two or more processes at the same time.

Units for Concrete Work.—The cost of a cubic yard of concrete may vary between about $6 for cheap pavement sub-base to about $30 or more, for certain parts of a reinforced concrete building. A hasty generalization drawn from such variations as this has led many an engineer to scout the usefulness of cost data, particularly such data as have not been gathered by the individual who attempts to draw conclusions from them. However, when the cubic yard of concrete is divided into proper sub-units of cost, it is astonishing to note the fading away of all seeming difficulties, either in estimating costs of concrete or in securing data upon which to judge the efficiency of workmen.

The labor processes in concrete may be classified as follows:

1. Receiving and storing materials.
2. Delivering materials to the mixer (loading and hauling).
3. Mixing concrete.
4. Transporting concrete.
5. Placing concrete.
6. Ramming concrete.
7. Finishing the surface.
8. Framing the lumber for forms.
9. Erecting forms.
10. Shifting and cleaning forms.
11. Taking down forms.
12. Shaping the reinforcing steel.
13. Placing the reinforcing steel.

Some of these processes may be still further subdivided, and frequently it is desirable to do so. While the cubic yard of concrete is usually a satisfactory unit for items one to six, it is clear that the square foot or square yard is a unit that must be used for item 7. Items 8 to 11 should be expressed in terms of the 1,000 ft. B. M. as the unit, and it is usually desirable also to use the square foot of concrete surface covered by forms as another unit for estimating the cost of work on forms. Items 12 and 13 should be expressed in terms of the pound of steel as the unit, since the number of pounds of steel per cubic yard of concrete varies widely.

Two or More Units for the Same Class of Work.—As just indicated, it is frequently desirable to use more than one unit of measurement. The unit on which the contract piece is based is usually a desirable one in which to express all items of cost. In addition to this, the cost of each item may be expressed in other units, such, for example, as the 1,000 ft. B. M. and the square foot of area for form work in concrete construction. Such units should be selected as will permit comparison not only of one day's work with another, but of one job with another, and frequently it is desirable to select units that may be used in comparing two entirely different classes of work.

Uniformity in Units of Measurement.—The economic importance of uniformity in units of measurement cannot be overestimated. To illustrate: The common unit of concrete work is the cubic yard, but it is customary to measure cement walks in square feet. Now this leads to many blunders, not only in estimating the costs of walks but in effecting reductions in cost. Not only does the thickness of cement walks vary widely, but the proportion of cement to sand in each layer of the walk is variable. Therefore, to say that it takes so many barrels of cement to make 100 sq. ft. of walk means next to nothing unless the plans and specifications for the walk are also given. For purposes of accurate estimating it is necessary to prepare tables of cost of mortars and concretes in terms of the cubic yard; then by remembering that 100 sq. ft. having a thickness of 1 in. are almost exactly 0.3 cu. yd., it is a simple matter to convert costs per cubic yard into costs per square foot.

Not only in computing costs of cement walks, and the like, but in reducing costs, does it aid us to use the cubic yard as the unit, for it enables us to make comparisons, and thereby discover inefficiency of workers. In Gillette's "Handbook of Cost Data" a case is cited where the labor cost of the face mortar for a concrete wall was out of all proportion to what it should have been. Had the contractor estimated the cost of this mortar in cubic yards, he would have discovered that it was excessive. The labor of mixing mortar should not be much greater than the labor of mixing concrete per cubic yard, nor should the labor of conveying the mortar in wheelbarrows be greater. The labor of placing it in a thin layer is obviously greater than for placing concrete in thick layers; but, in the case mentioned, the contractor was losing his money in mixing and conveying the mortar.

He had not recognized the fact because he had not reduced the cost of dollars per cubic yard of mortar.

In like manner, one may often see money wasted in making and delivering mortar to bricklayers and masons, because the cost of the mortar itself, in terms of the cubic yard of mortar (not of masonry), has not been calculated.

The cost of labor on forms and falsework should always be recorded in terms of 1,000 ft. B. M., as the unit; for that is the common unit of timber work, and, being so, ready comparisons can be made only in dollars per thousand feet B. M.

It is surprising how few managers of men have realized the value of reducing the cost of each item of work to units that are comparable; and by this we mean units in terms of which entirely different classes of work may be compared. Thus, in a brick pavement there is grout used between the joints. This grout is a thin cement mortar, and it averages, let us say, 6 cts. per square foot of pavement. Now, what does it average per cubic yard of grout? Probably not one paving contractor in a thousand knows; but, until he does know, he cannot compare the cost of grouting with the cost of other kinds of cement work. Many a time have we had our eyes opened to unsuspected losses and inefficiencies only by reducing the costs of the elements of work to units comparable with the units of similar work in other fields.

The ton is a very convenient unit to use when comparing the cost of loading and handling materials of all kinds. The ton of brick, the ton of gravel, the ton of timber, the ton of cast-iron pipe, are loaded upon wagons by hand at a cost differing not so much, one from the other, as might at first be supposed. When reliable data are not available for estimating the cost of handling any given material, by reducing it to tons an approximate estimate can usually be made that will be satisfactory, at any rate far more reliable than a guess.

Units of Transportation.—On contract work, distances of transportation are usually so short that the percentage of time "lost" by cars, carts, etc., while being loaded, becomes a very large part of the total day's time. Hence the unit of transportation must not be simply a unit of weight, or of volume, transported a unit distance. For example, a wagon may be loaded with earth in 4½ min. transported 100 ft., dumped and returned in 1½ min., or less; total, 6 min. Of this time less than

25% is spent in transporting the earth. On the other hand, if the haul is 6,000 ft., the time spent in transporting may be 93%. The cost per 100 ft. transported is almost four times as much in one case as in the other. Therefore, unless the hauls are so long that the time lost in loading and unloading is an insignificant part of the total time, it is essential to divide the work of transportation into three elements:

1. Time lost loading.
2. Time lost transporting.
3. Time lost unloading.

Often this third item is so small that it may be disregarded. On contract work it is often necessary to have a fourth item:

4. Time lost during the shifting of tracks, and other changes in plant location.

In brief, the lost time, of whatsoever nature, must be determined and deducted from the total time, before the number of units of transportation performance can be divided by the correct number of hours.

Transportation, therefore, must be divided into two main units of cost:

1. Non-productive (lost time loading, dumping, shifting plant, etc.).
2. Productive.

The total cost of the non-productive time is divided by the total number of yards or tons moved to get the unit non-productive cost of transportation.

The productive cost of transportation is the ton-mile, the cubic yard-mile, the ton-station (station = 100 ft.), or the like.

The distance of transportation is usually computed from a map, but it is often desirable to attach an odometer to one, if not all, of the wagons, locomotives, or the like.

Odometers of the kinds used on automobiles and bicycles can be advantageously used in a great many places on contract work, a few of which are as follows: On wagons, on wheel scrapers, on locomotives, on traction engines, on road rollers, on derricks (to record the number of swings), on hoisting engines, on cableway carriages, etc. Indeed, wherever a machine or tool has a revolving or reciprocating part, an odometer or counter can be used to record the number of reciprocations or revolutions, and from the data so recorded the amount of work can often be calculated with great accuracy.

Recording Single Units.—There are many classes of work in which the only practicable unit to be used is the single or individual unit itself; thus, the telegraph pole erected, the pile driven, the door hung, etc. Obviously records of units of this sort are so readily made as to require almost no comment.

A punch card is a convenient record of single units. Some contractors prefer a tally board on which each unit is marked or tallied with a pencil. Others use a board like a cribbage board, having holes in which plugs are put to record the number of units. Still others give out tickets to the men for each unit of work delivered.

Record Cards Attached to Each Piece of Work.—In doing machine-shop work it is often necessary to have one piece of metal pass through the hands of several different workers. For example, one man may drill holes of a certain size, another man may drill holes of another size, still another man may thread the holes, and so on. In such a case it is common practice, where careful cost records are kept, to provide a card that is attached to each piece or each lot of pieces. In blanks provided on the card, each worker enters his number, and the number of hours and minutes spent by him in doing a specified kind of work on the piece. A modified form of this method is to attach a card or a brass check to each piece, giving a serial number and letter to the piece. Each workman on the piece notes its number on his own record card, and opposite this number he enters the amount of time spent on the piece.

While this method of recording output cannot be as frequently used in engineering contract work as in machine shop work, it should not be overlooked by the general contractor. It might well be applied to timber work where one gang of men bores the holes, another gang saws and a third gang "daps" or adzes the sticks, and so on. It is desirable always to assign different kinds of work to different men, not only because the time usually lost in changing tools may be saved, but because men become more expert when they do one class of work only. The record card facilitates the differentiation of labor into classes, and is, therefore, a great aid in increasing the output of a given number of men.

Measurements of Length.—For a great many kinds of contract work the lineal foot is the best unit to use. Track laying, fence building, pipe laying, setting curb, etc., come under this

head. Many other classes of work are commonly measured only in terms of the lineal foot, when, to permit true comparisons, some other unit or units should also be adopted. Sewer work, for example, is commonly recorded only in terms of the lineal foot; but the amount of excavation varies greatly per lineal foot in different sewers and often in the same sewer; hence the excavation should be measured with the cubic yard as the unit.

Tunnel excavation should also be reduced to the cubic yard standard. A contractor has no very definite idea whether the "mucking" (loading of cars) in a tunnel is being done economically or not until he has determined how many cubic yards each man is loading daily.

Measurements of length are often best made by driving a line of stakes 100 ft. apart, calling each stake a "station." The starting point or station is called Station 0. The next station, 100 ft. from the start, is Station 1; the next station, 200 ft. from the start, is Station 2; and so on. Hence the mark on any given station stake gives the number of hundreds of feet from the starting point. Points intermediate—that is, between any two stations—are called "pluses." Thus, a point 40 ft. in advance of Station 2 is called "two plus forty," and is written Station 2 + 40, by which it is clear that it is 240 ft. from the start.

Having driven a line of station stakes, properly marked with their station number, a foreman or timekeeper can quickly ascertain the station and plus at which the day's work has been completed.

In many instances, measurements of length are best made by counting the number of pipe lengths laid, or the number of rail lengths.

Measurements of Area.—Paving, painting, roofing, plastering, and many other classes of construction work are best measured in terms of the square yard, square foot, or "square" (100 sq. ft.) as the unit. Since areas are usually measured with ease, it is noticeable that area work is generally done with much greater economy than mass work, which is usually more difficult to measure and consequently not measured every day on most jobs. It is sometimes not easy to measure the number of thousand feet board measure in concrete forms, in which case it may be preferable to measure the area of concrete covered by the forms, from which, if desired, the amount of lumber can be calculated approximately.

Measurements of Volume.—This class of measurements is usually the most difficult to make for purposes of daily output reports. Excavation, for example, is not easily measured, as a rule, except by a surveyor. Of massive masonry the same is true. Hence there are few contractors who know accurately how many cubic yards of this sort of work should be accredited each day to each gang. Record should be kept of the number of car or wagon loads of excavated material; but, to derive much benefit from such records, care must be taken to have cars and wagons of uniform size uniformly loaded, or to keep record of the capacities of the different vehicles. Where daily measurements of volume are difficult to secure, some one or more of the following methods may be adopted.

Method of Estimating Excavation Yardage Daily.—W. A. Gillette devised a method of estimating earth yardage on grading jobs every day. The method consists in mounting a timekeeper on a horse and having him ride from gang to gang all day long, stopping 20 to 30 min. at each gang. If a gang is excavating with fresno scrapers, for example, the timekeeper counts the number of fresno loads taken out by the gang in, say 20 min.; and he records the count for that gang. The he rides on to the next gang which, let us say, is loading earth by hand into wagons. This gang is timed for, say, 30 min., and the wagon loads are counted.

In the course of the day each gang is thus visited and its output counted several times. If, for example, gang No. 1 has been visited 3 times and during a total time of 1 hr. it has turned out 50 fresno loads, it is then estimated that it would turn out 400 loads in 8 hr.

An estimate is made of the average size of a load, and the total yardage output of gang No. 1 for that day is estimated. Similarly with the other grading gangs. At the end of the month the totals thus estimated are compared with a careful monthly estimate based on cross-sections. After a little experience it is possible thus to estimate within 5% of the actual yardage moved.

Of course this intermittent count method can not be expected to give satisfactory results unless good judgment is used in its application. But it has been shown to the author's satisfaction that the method is sufficiently reliable when properly supervised. That it is simple, is self-evident.

The two greatest obstacles to the successful use of any cost keeping system are, first, a fairly accurate measurement of the number of payment units of work done each day, and second, a correct ascertainment of the total time lost or wasted by each gang. By "payment units" is meant the units of work for which a contract price is paid, as, the cubic yard of earth excavation, the square yard of pavement, etc.

All costs should be finally reduced to so and so many cents or dollars per payment unit, so that the contractor can compare them with his contract prices. Fortunately the highway contractor has a relatively simple task in devising methods of measuring most of the payment units every day. Excavation measurements are the most difficult to secure daily, but a suggestion as to how this may be done has just been given. The yardage of pavement laid daily is readily ascertained. Since excavation and paving usually constitute the bulk of the cost of a road, it is evident that if a contractor can keep these two items of cost within his bid price, he can usually "win out" on the entire job.

Measurements of Weight.—Loaded cars or wagons can be weighed on track scales or on portable platform scales, and this can be profitably done far oftener than it is. Loaded skips and buckets can be weighed with spring balances attached to the hoisting rope of a derrick. It is sometimes very difficult to measure volumes of certain quantities in the field and it then becomes of advantage to weigh them. It is not easy to tell how much rock there is on a skip load without weighing the loaded skip either by placing it on scales or by putting a spring balance on the derrick. Spring balances of that character can be purchased of a capacity up to 3,000 lb. and costing about $300. Another form of rock measuring apparatus is in the nature of a balance, costing about $175. A great advantage of a spring balance on a derrick is that it takes no extra time for handling, and, while the first cost seems rather high, the information obtained on a large piece of work is well worth its cost.

In a good many of the Hudson River Trap Rock Quarries the stone is handled in cars which are pushed along on the tracks for purposes of weighing and the men are paid for performance according to the weights on the cars. This is a very accurate and, where it is practicable, a highly satisfactory method of measuring output.

This method has long been in use at coal mines where every car is numbered, and is weighed before dumping.

On contract work, such as macadamizing, for example, each wagon load may be weighed, if the amount of the work warrants the purchase and use of platform scales. It is usually considered sufficiently exact, however, to measure the size of a few loads, and simply count the number of loads. However, loads often vary so greatly in size that this method of counting loads becomes very unsatisfactory. This holds true particularly of loads of quarried stone, of earth loaded by steam shovels, and the like. In such cases the contractor should seriously consider the advisability of weighing each load.

One of the most difficult classes of construction work to measure daily is rubble masonry. Yet we have found two very satisfactory methods of recording the work done by each derrick gang. One way is to use wooden skips that are loaded at the quarry with stone, put upon cars and transported to the work. Each skip is provided with a clip for holding a brass check. The checks are numbered serially, and the weight of stone corresponding to each number is entered in a book; for before delivery to the masonry derricks each skip is lifted by a derrick, placed on scales and weighed. It is sometimes preferable to provide a large spring balance for weighing, instead of using scales. The mason in charge of the derrick gang removes the brass check from the skip and keeps it, entering its number on a card which is turned over to the timepeeker at night, together with the brass checks. Thus it is possible quickly to ascertain the number of tons of rubble laid by each gang.

Functional Units of Measure.—Under this head we class all measurements of units that are functions of the desired units. Thus, in any given mixture of concrete, the number of barrels or bags of cement is a function of (*i.e.*, it bears a definite relation to) the number of cubic yards of concrete. Hence a record of the amount of cement used each day will enable making a close approximation to the number of cubic yards of concrete.

In rubble or cyclopean masonry, a record of the number of buckets of mortar will enable making a close calculation of the yardage of masonry. If spalls are liberally used to reduce the amount of mortar, as they should be, then the number of buckets or skips of spalls should also be recorded.

The number of gallons of paint used is ordinarily a fair criterion of the area of surface painted.

By the use of packets for handling bricks, Gilbreth has developed a system of measuring the work done by each bricklayer, for count is made of the empty packets stacked up by each mason. Since each packet is loaded with a definite number of bricks, this gives an accurate record of each man's output.

Stockpile Measurements.—There are certain kinds of construction that are best measured indirectly by ascertaining what has been removed each day from the stock piles. Thus, in erecting a frame building, the different kinds and sizes of lumber can be piled in stock piles of regular size, easily measured. Rolls of paper, bundles of shingles, etc., can be stored in such manner that a daily inventory of stock on hand is readily made. By subtracting the amount shown by the inventory at the end of each day from the amount on hand the previous day, an accurate record is obtained of materials that have gone into the building. Since a carpenter's work is usually best measured in terms of the 1,000 ft. B. M., the square of shingles, and the like, it is evident that stockpile measurements can be used to great advantage in determining the number of units of certain kinds of work performed on a building.

The measuring of material is greatly facilitated by using a standard method of handling. Gilbreth's rule for cement (see his "Field System") is to place the bags one on top of the other in piles of 50.

One of the most difficult of the materials to check regularly is the reinforcing steel for concrete. By furnishing a table to the storekeeper, that will give the weight per linear foot of the various sized bars, they may be wired into bundles approximating 100 lb. each, this being a suitable amount for two men to carry. The bundles are, of course, nearly always more or less than 100 lb., and when the steel is wired it is a good plan to attach to each bundle a tag giving its weight, which tag can be left with the storekeeper for record as the bundles are removed to the work. The difficulty of obtaining these records is caused by the fact that the material is usually placed in a haphazard way wherever it happens to be most convenient for the men placing it without any systematic regard for its use on the work.

Key Units of Measure.—It is always desirable to relieve the foreman or timekeeper of the work of computing the number

of units of work done daily, wherever such computation involves either many measurements or much labor in computing. A foreman can readily report the number of "stations" of road graded or macadamized, leaving to the office force the work of deducing the number of units of work performed.

A further step in the same direction is the use of key letters and numbers to designate sections of work whose dimensions the foreman may not know but which are recorded in the office, and from which the number of units of work performed can be readily ascertained. For convenience we call these units key units, since they are designated by key letters or numbers.

Key Units on Drawings.—Any given structure can usually be divided into "sections" identical in shape and character of work. Thus, in a concrete building, there are a number of columns of identical size, a number of beams also identical, a number of identical floor slabs, and so on. To each of these "sections" a key letter or number, or a combination letter and number, may be assigned and written on the drawing.

If numbers from 100 to 199 are reserved for "sections" on the first floor, and the letter *C* is used to denote columns, then *C* 100 will designate a particular kind of column on the first floor; while *C* 200 will designate a corresponding column on the second floor. Having assigned keys to all "sections," the foreman or timekeeper is furnished with blueprints on which the "sections" with their respective keys are marked. In some instances it is preferable to furnish only a few large blueprints containing many "sections" on each print, but it is usually desirable to supplement these large blueprints with small ones of notebook size, which, if preferred, can be punched and bound in a loose-leaf binder.

The foreman or timekeeper reports daily the number of each class of "sections" built by each gang, using the proper key to designate each "section." The office force, having computed the number of units of work in each section, is then able to record the total number of units of work done, with accuracy and with rapidity. If a full "section" is not completed, the foreman or timekeeper estimates the percentage completed, and reports accordingly.

Keys Marked on Separate Members.—On certain classes of work a modification of the above plan is preferable. Instead of providing the foreman or timekeeper with drawings having keyed "sections," a key number or letter is painted, or otherwise

marked, on each separate member of the structure before it is put into place. Thus, each block of cut stone is measured in the stock yard and a "key" is painted upon it. Then, when the foreman reports that block *A* 105 has been laid in the wall, the office force can determine its volume from the recorded measurements. The authors have found this to be the most satisfactory method of recording cut stone work, for it is thus possible not merely to tell the total amount laid each day by several derrick gangs but to tell precisely what each gang has done, for each boss mason can be required to record the key number of every stone laid under his direction. The office work of computing the volume of each stone is insignificant in amount if tables are used for computation, such as Nash's "Expeditious Measurer." These tables give the volume of any block, progressing in size by inches up to 4 ft. 9 in. by 6 ft. 4 in. by 1 ft. 1 in. The tables also give surface areas, progressing by inches, up to 4 ft. 1 in. by 8 ft. 5 in. in size.

Structural steel members can be marked with key letters; so, too, can heavy timbers, movable sections of forms and falsework, and many other classes of materials used in construction work.

Conclusion.—Upon the ingenuity of the management engineer, who devises ways of recording the daily output of work done rests the success or failure of any effort to introduce modern methods of management on complicated contract work. The problem before him is often one to tax his ability almost to the elastic limit, for it is not sufficient to devise a method of measuring daily output after a fashion. He must devise not only an accurate method but one that permits of application at the hands of men comparatively unskilled mentally, and under the varying conditions that characterize field construction work. Many a contractor has given up in disgust his attempt to install a modern system of cost keeping, and has charged his failure to the folly of "new-fangled notions." Such failures are usually the outcome of trying to teach old dogs new tricks without so much as hiring a competent teacher. Eventually, it will be recognized that management engineering is a science not to be picked up and mastered at one reading of any article or book, but that it requires study extending over a considerable period of time.

Method of Reducing Idle Time.—The following notes are from *Engineering and Contracting*, Nov. 21, 1917. From time to time there is extended discussion of why contractors fail to make

money. One sees discussions of the subject bearing on almost all phases of the matter, but rarely is there any question as to the competency of the men who hold the contracts. And, indeed, this is not a surprising thing, for contracting is an honorable and an honored business, and many who engage in it are among the leading men of the day.

On the other hand, many small undertakings, especially in the line of public works, fall into the hands of men who are not possessed of great experience and who, no matter how well they intend to do, are nevertheless handicapped by this lack of experience. This has occurred to the writer repeatedly as he has had occasion to visit small jobs and has had opportunity to observe the wonderfully low efficiency in handling men which many small jobs show, and it has often been a question in his mind as to whether the ordinary foreman knows how to find out even the most elemental facts as to how steadily his men are working.

One very good way to do this is to find a place where one can watch a force of men at work without being too closely observed and then count the idle men, the count being repeated every minute over a period of 15 or 20 min. and repeated two or three times a day. Thus on a job in Iowa the following record was recently made:

On the job: One foreman, one inspector, eight laborers, in sight. (There were two or three others on the job who could not be seen from the point where the counts were made.)

Count	Men idle	Men at work	Count	Men idle	Men at work
2:31	4	4	2:41	5	3
2:32	4	4	2:42	7	1
2:33	6	2	2:43	7	1
2:34	3	5	2:44	4	4
2:35	8	0	2:45	6	2
2:36	5	3		—	—
2:37	6	2		74	46
2:38	4	4			
2:39	3	5	Average at work, 3+.		
2:40	2	6	Average idle, 5.		

The unescapable impression which this simple count gives is that more than half of the time of the men employed on this job

was being lost. If to this one adds the time of the foreman who in this case did nothing but "boss the job" the condition of affairs seems even worse.

There is nothing new or original in this simple count to determine the elementary question as to how much positively wasted time there is on a job, but if more contractors would adopt it there would be more of an effort to save labor by arrangements of the force which would eliminate the lost labor.

On the job in question, a mixer was running at full speed during the whole period of the count. It had been running for some hours before the count was taken and ran on after the count was made. Three of the eight men fed sand and gravel to the mixer. The sand and gravel were not separate, but were mixed together, the aggregate being a run of pit material used without screening. One of these men was always idle. Two should have fed the mixer with ease even though it seemed that the aggregate had been unloaded farther from the mixer than was necessary or advisable.

One man brought cement to the mixer. He was a dead expense, and idle over half of the time. The cement could just as well have been unloaded on a platform where the man who tended to the mixer could have gotten at it without assistance.

Another man pumped water for the mixer. A small power pump connected to the mixer engine should have handled this work. This man was idle two-thirds of the time.

The man to tend the mixer was needed, but the man who dumped the mix and shoved it down a trough set at a light slope when it should have been set steep enough to permit the concrete to run or, better still, when the mixer should, as in this case, have dumped direct into the forms, was a dead loss.

The man who tamped the concrete in the forms was needed, but he should also tended to dumping the batches as they were mixed. Thus, careful management would have cut this force of eight men to four men and it is not asserting too much to say that none of the four would have been overworked.

Inquiry was made as to the financial side of this job. It had lost money! No wonder. Using two men to do one man's work is seldom profitable.

CHAPTER V

COST KEEPING

Objects of Cost Keeping.—The two primary objects of cost keeping are:

1. To enable a manager to analyze unit costs with a view to securing the minimum cost possible of attainment under existing conditions.

2. To provide data upon which to base estimates of the probable cost of projected work.

As a result of the analysis of unit costs, followed by a comparison of the items with corresponding cost items of similar work previously done, a manager may discover;

1. Excessive use of materials in erecting a given structure.

2. Excessive use of supplies (coal, etc.) in operating a plant, whether due to ignorance, carelessness or theft.

3. Inefficiency of workmen.

4. Inefficiency of foremen.

5 Padded payrolls.

6. Excessive loss of time due to: (*a*) plant break-downs, (*b*) plant shifting, (*c*) waiting for materials or supplies, etc.

7. Improper design of plant.

Cost keeping also leads to the introduction of piece-rate or bonus systems of payment, which may, in fact, be said to be one of the ultimate objects of cost keeping.

Cost keeping secures many incidental advantages, like the following:

1. Fewer "bosses" are required on certain classes of work, for the report card is a more persuasive stimulus than the eye of a taskmaster.

2. One skilled manager can direct many more men, and with much greater effectiveness than is possible where a cost keeping system does not exist.

3. Systematic analysis of costs leads inevitably to a study of reasons for differences in costs, and this study of reasons is the first step toward inventing new machines and new methods for reducing costs.

Cost Keeping Defined.—For the purpose of the discussions in this book, a distinction must be drawn between bookkeeping and cost keeping.

Bookkeeping, as we treat it, is the process of recording commercial transactions for the purpose of showing debits and credits between different "accounts." These "accounts" may be individuals or firms, or they may be arbitrary accounts, the latter being an evolution in bookkeeping that came after individual accounts became so large or so complicated as to be insufficient to show the status of the business and the profits derived from any given transaction.

Cost keeping, as we treat it, is the process of recording the number of units of work and the number of units of materials entering into the production of any given structure, or into the performance of any given operation. To these units of work or materials, actual or arbitrary wages or prices may or may not be assigned. The object of cost keeping is primarily to show the efficiency of performance; hence actual money disbursements need not be recorded, as in bookkeeping. This distinction is vital, and will be discussed at greater length.

Differences Between Cost Keeping and Bookkeeping.—Bookkeeping was first devised and subsequently developed by merchants. Cost keeping was devised and developed by engineers. The merchant is a student of profits; the engineer is a student of costs. Although profits depend upon costs, there is a vast difference in the point of view of the merchant and the engineer.

In the study of costs, as we have previously pointed out, the aim of the engineer is to reduce all costs to a unit basis, selecting such units as most closely conform to the theoretical unit of work—the foot-pound. This study often necessitates the use of several different units for the same class of work. It necessitates the recording of conditions, and the making of measurements—all of which is more or less foreign to the fundamental idea of bookkeeping. Yet, in groping toward methods of cost keeping, it has become the practice of most contractors, manufacturers, railway companies, etc., to endeavor to develop a cost keeping system in the bookkeeping department. Hence we have today systems of bookkeeping that are wonderfully complex, and, withal, show very little that they attempt to show as to unit costs.

Take, for example, the accounting department of an American railway. Here we find skilled accountants loaded up with a mass of work called for in distributing the costs to different accounts. Calculating machines that carry the cost of railway spikes out to the third decimal place are clicking away from morning to night. A prodigious amount of figuring is done so that scores of distributions may be made, without the error of a cent in the balancing of accounts. Yet, with it all, what do these railway accounts show as to unit costs? Next to nothing worthy of the name of cost keeping. The authors have in their possession a mass of railway accounting records; some of it of great value, but most of it valuable only to show bookkeeping gone mad. The accounting department of the average railway has no true record of unit costs. The average railway engineering department is even worse off, as shown by the ridiculous estimates often submitted. After a structure is built, the auditor of the railway takes the superintendent of construction to account for having exceeded the engineer's estimate. The engineer is put on the rack and calls the superintendent inefficient—which is usually true. The superintendent retorts, in his letter to the accounting department, that the engineer does not know how to estimate correctly—which, also, is usually true. Figures, figures, figures, but not a single unit cost! This is typical of railway accounting costs today. We emphasize it because it is also typical of the accounting departments of many contracting firms. And we emphasize it again because it illustrates so well our contention that bookkeeping and cost keeping must be divorced if there is to be a simple, effective system of ascertaining the efficiency of workmen, and permit of such study of their performance as will result in greater efficiency.

Why Cost Keeping Records Should Be Kept Distinct from Bookkeeping Records.—Many contractors and engineers confound cost keeping with bookkeeping and attempts are often made to make a cost keeping system so elaborate as to be a bookkeeping system, thus burdening the bookkeeping with a great deal of material that is not germane to it and piling the cost keeping under an avalanche of details and figures that are destructive to its economic value.

Bookkeeping is an ancient art. Cost keeping is a development that is less than a generation old. Since cost keeping has resembled bookkeeping in some respects, it has been regarded as

an evolution of bookkeeping, when, in fact, it was not originated by accounts nor developed as a part of accounting. We repeat that cost keeping has been evolved and developed by engineers, not by bookkeepers. It is an art and a science having objects differing radically from the objects of bookkeeping. Yet innumerable blunders have been made in the attempt to graft a cost keeping system upon a bookkeeping system. These blunders arise from a misconception of the functions of cost keeping and bookkeeping. Let us consider still further what bookkeeping is and wherein it differs from cost keeping.

Bookkeeping in its original and simplest form consists of a record of debits and credits. Its primary object is to show obligations between individuals or corporations. By an extension of this idea, arbitrary accounts were created, such as Bills Payable, Profit and Loss, etc.; but, in all cases, the accounts were kept in the form of debits and credits. Hence the general object of bookkeeping is to show debits and credits.

Now, what is the object of cost keeping? Primarily, its object is to show unit costs. These unit costs may be used as standards by which to effect reductions in costs, or as standards by which to estimate the cost of future work. Cost keeping, therefore, involves the use of standards of comparison, which do not enter into bookkeeping in its original form, nor can the use of standards be grafted upon bookkeeping without great confusion and complication. As above stated, perhaps the best example of the confusion and complication that follow such an attempt may be found in the bookkeeping of railway companies. Without discussing the matter at this time, we need but refer to the absence of satisfactory unit costs in the accounting records of railways and the great labor involved in digging out the data necessary to derive unit costs of the kind most useful to the engineer. The labor wastes that undoubtedly occur in railway construction and operation are attributable to the hybrid system of accounting which is supposed to be good bookkeeping and good cost keeping, without being good in either respect. Nor shall we dwell upon the inability of the chief engineers of railways to estimate costs accurately further than to point out that the accounting records are so involved as to be of little or no assistance to them.

We shall now give in concise form some of the various reasons

why cost keeping records should be kept entirely distinct from bookkeeping records.

1. Since the primary object of *bookkeeping* is to show debits and credits, all accounts must be summarized in one book—the ledger. Since the primary object of *cost keeping* is to reduce costs, no book corresponding to a ledger is needed. Indeed it is often desirable to have cost records of different classes of work kept in different books, in different ways, by different men, in order to localize responsibility as well as to apply different units as standards of comparison.

2. *Cost keeping* should partake of the nature of daily reports by which a superintendent can gage the daily performance, and discover inefficiency at once. *Bookkeeping* accounts may not be, and usually are not, posted promptly or completely until some time subsequent to any performance.

3. *Bookkeeping* records must balance to a penny. *Cost keeping* records need not be kept with mathematical precision, except in so far as bonus payments to workmen are involved. The object of cost keeping is to show efficiency, and this may usually be shown by approximations fully as well as by hair splitting exactness. Hence cost keeping records may be devised that will require far less clerical work than is necessary when mathematically accurate bookkeeping is used.

4. *Bookkeeping* is a clerical function; *cost keeping* is an engineering function. It is a rule of successful management not to ask one man to exercise many functions, particularly when they are diverse in nature. An engineer is not interested in recording debits and credits, or in the rendering of bills—functions of the bookkeeper. On the contrary, a bookkeeper knows nothing about construction methods and not only has little interest in construction costs, but lacks the necessary engineering training to interpret cost records and to devise methods of reducing costs.

5. A contractor who has an effective and simple system of bookkeeping naturally objects to a change to a more complex system, such as is necessary when cost keeping is added to the bookkeeper's duties. Gilbreth's "Office System" contains an admirable method of bookkeeping without books, which is kept wholly distinct from cost keeping.

6. When cost keeping is begun, it is well to start in a small way, taking some particular kind of work, like teaming, and

applying a system of daily reports. When this phase of the work has been analyzed and organized, some other feature is taken up, and so on, thus developing a cost keeping system gradually. Resistance to change is bound to be encountered, and the way to overcome it is in this manner, a little at a time. Bookkeeping can not be changed a little at a time. A new system of bookkeeping means an entire revision all at once, for accounts are interdependent.

7. Cost keeping records should state conditions, such as weather, distance of haul, etc., which are essential to interpretation of results. Sketches showing design of structures should form part of permanent cost records. Such things are entirely foreign to bookkeeping, and, if placed upon bookkeeping records, simply serve to confuse them.

8. The bookkeeper enters bills for materials as they are received, crediting the firm that furnishes them. A barrel of spikes may be followed by a dozen picks on the bill. It is not the bookkeeper's function to trace the spikes to their place in the work, and, when the work is finished, to ascertain the total number of barrels of spikes used in a particular structure. That is the function of the cost keeper on the ground. The bookkeeper must show that John Smith Co. has been credited with the spikes. The cost keeper, on the other hand, cares nothing as to the particular firm credited. He is concerned only with the quantity of spikes and the use to which they have been put. It is hopelessly confusing to try to show in one set of records both credits, and unit costs.

9. In studying cost records to ascertain efficiency, it is often necessary to have several different units as standards. On reinforced concrete work, for example, the primary unit is the cubic yard, but there should be at least three other units, namely, the pound of steel (for comparing costs of handling and placing the steel reinforcement), the thousand feet B. M. (for comparing costs of forms), and the square foot of exposed surface (not only for comparing costs of form work but costs of surface dressing). Cost records must be sufficiently detailed for these purposes, if not in every case, at least in some cases of concrete work. Bookkeeping records become hopeless of interpretation unless they are uniform, and, to be uniform, they must have few units of comparison. In brief, bookkeeping is not flexible. To generalize further, cost keeping costs must be divided by units of work

done, so as to secure unit costs for comparison, which is a process foreign to bookkeeping.

10. Since cost keeping has as its primary object the reduction of costs, since comparisons of results secured by different men or different machines or different methods are necessary, it follows that standard wages and standard prices of materials must be used. It may happen that on one job the cement may be purchased at different times at prices ranging from $2.20 to $2.50 per barrel, and that common laborers may receive from $2.50 to $2.75 a day. In comparing unit costs a standard price of cement should be assumed, as $2.30 per barrel, and a common labor standard wage, as $2.50 per day. Then comparisons become possible. A bookkeeper cannot assume any rate of wage or any price; he must give the actual wage or price. A cost keeper usually finds it desirable to use standard wages or prices which approximate, or actually are, the average.

With the wide variation in wage rates as a result of the World War, it is considered more desirable to record labor costs on the man hour basis.

With all cost records it is essential to record the size and type of equipment used and any special conditions tending to govern the output.

Conversion Factors in Cost Keeping as an Aid to Management. There are many kinds of work involving a multiplicity of slightly varying conditions affecting the unit cost, and in such cases it may appear almost useless to ascertain the unit cost. Thus, in setting poles some of the cost variables are: Character of digging, topography, depth of hole, length and class of pole, number of poles involved in one job, obstructions such as trees or existing lines of wire, rate of wages, etc. In spite of all these variables it is possible so to determine unit costs of pole setting as to make rational comparisons of the costs on one job with those on another. This can most readily be accomplished by the use of what may be termed conversion factors.

A conversion factor is the ratio of unit cost under an assumed standard condition to unit cost under a given condition that varies from the standard. Thus, the unit cost of digging a pole hole 5 ft. deep and 2 ft. in diameter in loam may be taken as a standard when wages are $2 a day when the men work steadily 8 hr. a day at digging holes. Let the resultant average unit cost of digging be 50 cts. under these standard conditions. The first

and most obvious conversion factor is one that provides for lost time due to rain or other conditions beyond the control of the workmen, for which their pay is not "docked." If, for example, rain causes a loss of 1 hr. in the day, the resulting $2 wage becomes 28.6 cts. per hour for the 7 hr., as compared with 25 cts. per hour for the standard 8 hr.; hence, the conversion factor for 1 hr. of lost time is 28.6 ÷ 25 = 1.144 or 1.1/7.

By timing the number of minutes required to dig the standard size hole in different kinds of soil, conversion factors for soil conditions are derived. Thus the conversion factor for clay of a given sort may be 1.3, for hardpan 2.5, and so on.

In similar manner conversion factors for holes of different sizes and depths are derived by minute-hand timing.

The number of holes involved in one job affects the cost per hole. If there are too few holes to keep the men busy throughout the day without the loss of time moving to another job, the time lost in moving increases the unit cost. Of course it would be possible to group this lost time with time lost because of bad weather, but it is not desirable to so do. **Time lost due to conditions entirely beyond the control of the manager should not be merged with time lost under conditions that are more or less controllable.** Altogether too much maintenance and construction work is done in small jobs far apart, and without adequate provision for rapidly moving the men from one job to another. The job-size conversion factor calls particular attention to large unit cost of small job work, and leads to study of means of reducing the time lost in moving and getting started.

Rates of hourly wages differ in different localities and in the same locality at different times. Also where small gangs of men are moved about over considerable distances, it is frequently necessary either to increase their wage or to pay their board. Some gangs are not paid for holidays; other gangs are. These and similar causes affect the average hourly rate and make close comparisons of unit costs impossible unless wage rate conversion factors are used.

It is rather astonishing how seldom this cost factor is given adequate consideration, particularly when it is so readily determinable. The explanation of remissness on the part of managers in this respect probably is found in their general attitude toward unit costs as criteria of efficiency. Confronted by many variables they are apt to make no attempt to study the effect even of the

variables that are readily analyzed. Almost every variable can be rather easily taken into account by the conversion factor method, and none more easily than the wage variable.

In the stringing of wire there are fewer variables of importance than in digging pole holes, yet even these few variables are rarely studied, and almost never used to establish conversion factors. Whether two wires or 12 are strung at one time makes an enormous difference in the cost of stringing per circuit mile. Still, a foreman often speaks with pride of his low unit labor costs of wire stringing, when the true credit for the low cost is assignable not to him but to the large number of circuits put up at the same time. Conversely, short wiring jobs of single circuits strung through trees show seemingly enormous unit costs for labor. By timing the added number of minutes involved in trimming each tree and the delay that it causes in wire stringing, tree-trimming conversion factors are derived, necessitating only on the part of the foreman or timekeeper the recording of the number of trees of a given class to a given number of poles.

Each foreman should be provided with a table of conversion factors and a brief statement of the conditions and number of units that he is to record each day. The ordinary foreman should be required to do little or none of the calculation involved in making the extension where the conversion factors are applied. This should be done in the office with a slide rule. But each foreman should afterward be given daily, weekly or monthly statements of the unit labor costs, reduced by the conversion factors to the common or standard units. Rivalry among different foremen is aroused when periodic statements of unit costs under each foreman are sent out. Even under the existing methods of cost keeping where conversion factors are not used, desirable rivalry is secured by issuing unit cost statements. But the existing method falls far short of what is attainable in this respect by the use of conversion factors. Foremen know that conditions vary to such a degree that the ordinary unit costs (without reduction to a standard unit) are often meaningless.

Time Keeping Defined.—Time keeping, in its old fashioned sense, is a part of the bookkeeping system, and the time keeper is charged with the task of ascertaining what time each man has worked during the day, week or month, according to the arrangement unber which he is employed, and what amount of money is due him on pay-day. The timekeeper was not concerned with

how much work a man did or on what process his time was spent, so long as the general distribution of the work was obtained. Of late years the timekeeper's distributions have become much more elaborate and now he is often charged with considerable cost keeping responsibility. When he does cost keeping work, the records should ordinarily be kept on separate blanks from the time keeping.

If a time keeper, unaided, attempts to distribute the labor according to the work done, his records become complex and are rarely reliable, for, due to his going from place to place, he must rely upon what others (like foremen) tell him as to the performance of different men. In his attempt to balance the statements made to him with the total time, he usually "doctors" his distributed records.

Hints for the Timekeeper.—The *Iron Trade Review*, Oct. 14, 1915, discusses the importance of "personal touch," as a method of increasing the efficiency of employes, as follows:

Every employer who has a real and heart-felt interest in all that is included in the three words "Safety, Sanitation and Welfare," wishes he could get into closer personal touch with his employes. Of course, if to him, safety, sanitation and welfare are merely empty words that cover a pharisaical pretense towards humanitarianism, or the chasing of fads and foibles, he has no interest in the personal touch and the employe is merely a machine with a capacity for so much output per day.

But there are good grounds to hope that employers of this type are becoming scarcer than they used to be because the evidence is accumulating to prove that the efficiency of a man to a great extent depends upon the attitude of the man toward his job. There is no doubt whatever that the average man can make himself more efficient if he wants to. How to make him want to is the real question. He can increase his output, reduce the hazard, avoid waste, and promote the general welfare if he is so inclined, but, if not so inclined, he can be a source of loss and discontent and an all-round breeder of trouble. Which kind of a man he will be depends to a great extent on his attitude of mind toward his job. Employers who are animated by "enlightened self interest" know this and are open to suggestion as to how men may be brought into such a mental attitude toward their jobs as will increase and not decrease their efficiency. The purpose of this brief paper is to make such a suggestion.

Around a mine the employe who comes most frequently into personal contact with every man on the job is the timekeeper. It goes without saying that he should be honest and accurate, but honesty and accuracy are not the only qualifications he should possess, if he is to do all that can be done in his position to promote efficiency. Neill Hutchings, of the Tennessee Coal, Iron & Railroad Co., in a little pamphlet that is excellent reading, has emphasized the necessity of courtesy and a kindly way in contrast to the short, brusque, curt manner that, unfortunately, is affected by too many timekeepers. He insists that the most dense and ignorant foreigner is entitled to courteous treatment from the timekeeper, clerks and the paymaster. They are the custodians of the fruits of his labor. He is entitled to receive at their hands that degree of courtesy and consideration that is supposed to obtain between man and man. The very fact of his ignorance and stupidity should appeal to those who are more fortunate in their mental qualifications and should be reason enough for refraining from that brusqueness, not to say brutality, that sometimes is in evidence. It is not good business to antagonize men needlessly. It is good business to conciliate them and evince toward them a manly friendliness.

Merely putting down the daily record of labor done should be but a small part of the timekeeper's usefulness. His job is one of personal touch; furthermore, he is not a boss. The superintendent is far removed. Whether he wants it or not, he is aloof from the men. The foreman, or shift boss, is to a degree the same. He wields authority. It is his business to direct, reprove and order. He must be extremely careful not to appear to play favorites. Here is where the possibility of the timekeeper's job comes in. Once or twice a day he meets each man face to face. If he made of the right stuff and animated by the right motives, he can be their friend. He can learn why Mike Mickilovich is not at work, and how matters are coming along in the fued that is brewing between the Austrians and the Serbians. If there are rumblings of a gathering storm, his ear can be to the ground. If the shift boss is a tyrant, he can know it. If the men have a real grievance, he can scent it far off. If some poor fellow is carrying a burden greater than he can bear, he can at least obtain a knowledge of the load. Presumably it is this sort of information the superintendent wants, if he is the kind of superintendent that knows that the personal touch is conducive to efficiency.

But this does not imply that the timekeeper's job carries with it that of tale-bearer, or spy. It only implies that he should have human sympathy and full recognition of the rights of man; a sense of justice, and a desire to use the peculiar advantages of his position for the promotion of harmony, and for helping the superintendent with knowledge of the actual conditions as they obtain among the employes, without which the superintendent is lacking one of the factors which make toward his efficiency as a superintendent.

There is no other subordinate job around a mine that covers so much territory; that takes in the underground workings and the office; that reaches from the top of the head frame to the pump station, like that of the timekeeper. A wide-awake timekeeper has a better all-around view of the operation of a mine than many a mining engineer. Because of the chances that the job lends toward learning the operating details, it should be sought after, providing the pay is at all adequate, by men who hope to advance in the business. Because of the peculiar possibilities the job presents for usefulness other than merely keeping the timebook, men should be sought after to fill it who can bring to it all those indefinable elements of courtesy, humanity, kindness, consideration and interest in the welfare of their fellow workers which go to further that much desired, if somewhat indeterminate, and called personal touch. There would appear to be evidence enough to show that in the selection of timekeepers these other qualifications have, in some cases, been sadly overlooked, much to the detriment of that ideal of harmony and team work which every superintendent is supposed to cherish.

All of which is respectfully submitted for the consideration of superintendents when necessary to select timekeepers.

Photographs as Records.—The value of photographs as records of construction work cannot be overestimated. If dated, when taken, photographs are not only useful in showing the progress of work, but also show in detail local conditions and the methods of carrying out the job.

Photographs should be taken from two or more directions depending on the size of the work. They should be of a uniform size and preferably of dimensions to file properly with the cost records. However, if this is not possible, they may be of any size up to standard letter size ($8\frac{1}{2}$ by 11 in.) and filed in a special

photograph file so that no delay will be experienced in getting at the information shown.

It is desirable to use a camera fitted with as excellent a lens as may be procured, taking a picture of moderate size, say 3¼ by 4¼. With a camera of this description a greater number of pictures may be taken for a given expenditure than with a larger camera. If large prints are desired of certain negatives, enlargements may be reasonably made which will be, depending upon the quality of the lens, equal in clearness and detail to pictures taken by a larger camera.

Daily Cost Reports, By Whom Made.—Daily cost reports may be made by: (*a*) individual workmen, (*b*) foremen, or (*c*) timekeepers, or by all three of these classes of employees.

Individual workmen are not always competent to fill out reports properly, but if the report is simple in form and relates to work done by "skilled workmen," it is usually possible to get very satisfactory results. Certainly the individual report is to be encouraged wherever it can be applied for it heightens the individual's interest in his work.

On field contract work the foreman is the man usually required to make the daily reports. His constant presence on the work enables him to make a more accurate report than a timekeeper can make, if the timekeeper is required to cover considerable territory, as is usually the case.

In addition to his duty in keeping the time of the men for surposes of paying them properly, the timekeeper is often able to attend to filling out the daily cost reports, or one or more special timekeepers may be appointed for the special purpose of rendering daily cost reports. If the timekeeper is not able to be present constantly where a gang is at work, it is often wise to prepare certain blanks upon which he receives reports from the foreman of the gang, and, from these foreman reports and reports of individuals, combined with his own observations and measurements, the timekeeper is able to fill out the complete daily report.

No hard and fast rule can be laid down as to the best persons to whom report making is to be entrusted. The character of the workmen, the size of the job, and other conditions govern the choice.

Written Card *vs.* Punch Card Reports.—Daily cost reports are best made on forms or blanks, and these forms are preferably

cards in which the blank spaces are marked either in writing or by punching holes with a conductor's punch. The written card possesses the following advantages over the punch card:

1. It is more flexible, because the punch card is limited in the scope of the record to what has been foreseen in the office plus what can be written in a small space reserved for remarks. The pad and pencil are not so limited.

2. A man can usually go ahead filling out blanks in a written card without any previous directions, while he has to have some instruction in the use of the punch.

3. Erasures are possible with pencil and pad but not with a punch card. This is not always an advantage on the side of the written card, however.

The punch card possesses the following advantages over the written card:

1. By folding the card, or by superimposing one card on another, a duplicate record is secured without the use of the carbon paper necessary to secure duplicates with written cards. This duplicate record cannot be altered or erased, and one copy may be kept by the superintendent for his record in discussing the work with the home office, the other being sent in as a regular report to the proper department.

2. A dirty thumb can greatly interfere with the legibility of a written record. Moreover the average foreman or timekeeper does not write a particularly clear hand. Punch card records are absolutely clear and legible.

3. It is sometimes expedient to have records from two or more men on the same card. By having no two punches alike on the job and having each man's punch charged to his name on the records it is possible to have a clear and complete record of who made the record without wasting time and space for signatures.

4. The hole made by the punch is usually less than one-eighth of an inch in diameter, and consequently a much larger number of facts can be recorded upon a small card by the punch than by writing, the number of groups of facts, however, being somewhat limited.

5. To punch a hole in a card takes much less time than to make the average pencil record especially where duplicated records are made. Where a timekeeper has to keep track of a large number of men this is a very valuable feature.

6. A hole can be accurately punched while riding on a hand-car,

wagon or locomotive, when the vibration would greatly distort a man's handwriting.

7. Punch cards can be made on blue print paper from a tracing, which is an advantage where a mimeograph is not available for making white cards to be filled in with pencil.

Time Cards That Show Changes of Occupation.—In field contract work there is usually more or less change of occupation constantly occurring. A gang of workmen may be engaged in grading for a while and then may be shifted to track laying; or at least some individual in the gang may be thus shifted from one class of work to another. Hence it is usually desirable to have daily report cards arranged so as to record the exact amount of time spent by each individual on each class of work. This may be accomplished in either one of two ways: First, by having a separate card for each workman; or, second, by having a gang card on which each workman's name or number appears, and so arranged that his time may be placed opposite or under the tabulated class of work that he has performed.

The individual card (a card for each workman) is often preferable when the bonus system, or its equivalent, is employed. On most contract work, however, the bonus system is not yet in operation, and gang cards, filled in by the foreman, will serve the purpose of showing the total performance of the gang and the times spent by the various individuals on different work. There are several ways of recording the individual times spent by men working in a gang, among which the following are typical.

Each employee is given a number, and the numbers are arranged in a horizontal line across the top of a time sheet, as shown in Fig. 2. The different classes of work are printed in a column at the left, one line being assigned to each subclass. If team No. 1 works from 7 to 9 A.M. plowing, the record is made by the foreman, who writes 7–9 opposite "Plowing" and under No. 1; since this is 2 hours' work, the figure 2 is subsequently written directly below the 7–9. If team No. 1 is then transferred to work connected with rolling subgrade, and is thus engaged from 9 to 11 A.M., this fact is indicated, as shown, by writing 9–11 under No. 1 and opposite "Rolling Subgrade."

Another method involves the use of "key letters" to indicate each class of work, the proper key letter being placed opposite the employee's name and under the nearest half hour when he began

doing the class of work represented by the key letter. Figure 3 shows that employee No. 1, whose name is Smith, began work at 7 A.M., the key letter *A* being under 7, and that he was engaged in excavation, since *A* is the "key" for excavation. He

Street ________________ *Date* ________________ 190__ | *City* ________________

No. of Employee		1	2	3	27	28	29	30	31	32	33	Total Hours
Grading	Plowing	7-9 2										
	Excavating											
	Rolling Subgrade	9-11 2										
Concrete Base	Hauling & Loading Concrete Gravel	11-12 1										
	Hauling & Loading Concrete Stone											
	Hauling & Loading Concrete Sand											
	Laying Concrete											
	Hauling & Unloading Cement											
Brick	Hauling & Unloading	1-6 5										
	Laying Brick		7-8 1									
	Making Cushion		8-12 4									
	Hauling & Loading Cushion Sand											
	Culling Brick		1-3 2									
	Rolling Brick											
Filler	Putting in Filler		3-6 3									
	Hauling & Loading Filler Sand											
	Putting in Expansion Joints											
Sewerage	Putting in Sewers & Inlets											
	Putting in Catch Basins											
	Putting in Manholes											
Sand	Screening Sand											
Curbing	Hauling & Loading Gravel or Stone											
	Hauling & Loading Sand											
	Hauling and Unloading Cement											
Sundries	Hauling & Loading filling Gravel or Sand											
	Cleaning up											
	General											
Macadam	Rolling Stone											
	Spreading Stone											
	Total Hours	10	10									
	Rate Per Hour	35	20									

All remarks must appear on the other side

________________ Foreman

FIG. 2.—Time card showing changes of occupation.

continued on excavation until 10:30 A.M., when he began back filling, as shown by the key letter *C* entered under 10 and in the lower square. The upper squares indicate the even hour, and the lower squares indicate the half hour. At 3 P.M. he was

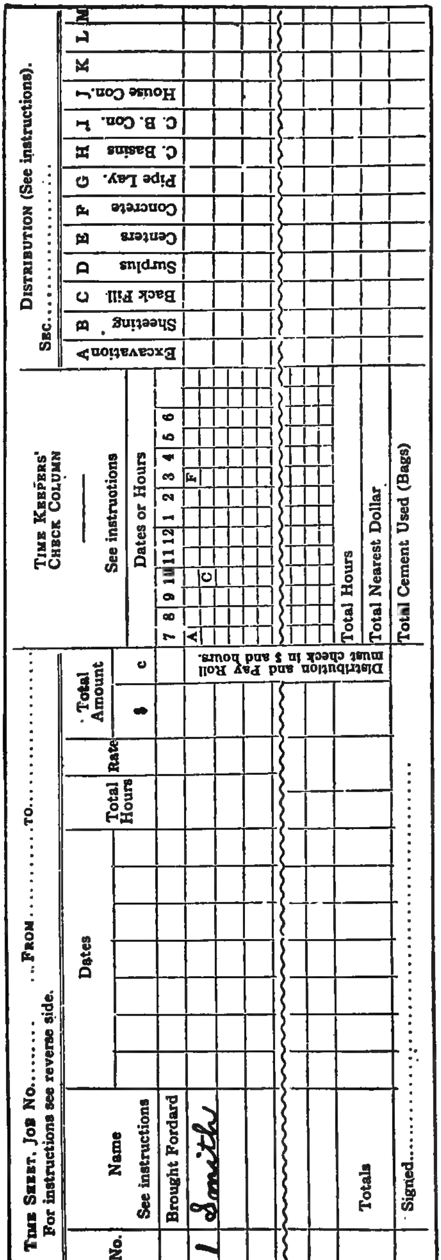


Fig. 3.—Time card showing changes of occupation by means of key letters.

transferred to concrete work, as shown by the key letter *F* under 3.

A modification of this last method is shown on page 344 where it will be seen that the number of hours worked by each man on each class of work is recorded under a column headed with a combination of key letters that indicate the class of work.

On some classes of work, a gang of men is seldom split up, but the entire gang may be shifted from one class of work to another. A method of keeping a daily "log" of events, showing at the same time the number of units of work done, is illustrated on page 413.

Wherever men are being frequently shifted from one class of work to another, some method of recording the time of shifting, at least to the nearest half hour, should be used, as outlined in the different ways above given. If a foreman does not make an immediate record of such shifting, but re ies upon his memory to fill in his report blanks at night, he is almost certain to make serious mistakes. Moreover, it is not unusual for a foreman to "doctor" the reports thus made, and even to falsify them grossly, for the purpose of showing a seemingly high efficiency of the men on certain classes of work; but, if a blank must be filled in during the progress of the work, and not at night, a foreman risks discovery of any attempted deceit, since his record card may be examined at an unexpected time of the day.

Gang Report Cards.—These are usually made by the foreman in charge of the gang. If the gang is always engaged on the same class of work, it is not necessary for the foreman to keep a time record of each man's occupation, in the manner just described; for the foreman can fill in the daily report card from memory. In this case the *timekeeper* records each workman's name and hours of work, while the *foreman* concerns himself only with reporting the total number of men engaged on each class of work and their day's performance.

A gang-report card should usually show most of the following things:

1. Number of contract.
2. Location of the job.
3. Character of the job.

4. Date of the report.
5. Kind of weather.
6. Name of the foreman.
7. Classification of work, or "key letters."
8. Total hours' labor under each class.
9. Rates per hour.
10. Total pay.
11. Number of units of each class of work done.
12. Units of material and supplies used.
13. Units of materials received.
14. Units of material in stock.
15. Delays, time and cause.
16. Time machines are actually working.
17. Kind of machine or tool used and its condition.
18. Remarks.

Obviously there are many classes of work that do not require a daily statement containing all these 18 facts; but in preparing a daily report card it is desirable to have this list at hand, to make sure that no omissions occur.

The space reserved for "Remarks" is usually so small that it is rarely used. Special conditions that would naturally be recorded under "Remarks" had better be recorded in a loose-leaf diary kept by the foreman, of which more will be said later.

In designing a gang report card, the most difficult feature is the classification. This, however, is greatly simplified if done according to the following system:

1. Select for the general class heads the items upon which the unit contract prices are based, such as excavation (cubic yards), macadam (square yards), curb (linear feet).

2. Divide each of these pay items into the *operations* involved. Thus excavation involves (*a*) loosening, (*b*) loading, (*c*) transporting, and (*d*) dumping.

3. Divide each operation into as many subheadings as there are classes of workmen engaged upon it. Thus, the operation of loosening earth may involve (*a*) teams plowing, and (*b*) men holding plow.

Summing up we would have the following subclasses under the class Excavation:

Excavation—
Loosening: Men holding plow.
Teams plowing.
Loading: Men shoveling.
Transporting: Teams.
Dumping: Men.

The next thing to consider is whether the men are of the same class, receiving the same rates of wages; for, if they are not, there must be a further subdivision. For example, on cement curb construction, the classification would be as follows:

Curb—
Trenching: Laborers.
Placing cinders: Laborers.
Mixing and placing: Laborers.
Setting forms: Skilled laborers.
Finishing: Skilled finishers.
Helpers.

There are many kinds of pay items, such as macadam, that often involve processes that are performed at widely separated places. Thus, quarrying and crushing are processes far removed from spreading, rolling and sprinkling the macadam. Whenever this is the case, it is usually unwise to attempt to show all the processes on one report card. A good general rule to follow is to group together on the same report card only those processes that come directly and constantly under the eye of one foreman. Therefore one report card should show the quarrying and crushing, another should show the grading of the road; and possibly the spreading, rolling and sprinkling of the macadam should also be placed upon the same card with the grading, but not unless the grading gang is to be always a very short distance in advance of the macadamizing.

The commonest mistake in designing report blanks is to endeavor to reduce the number of the blanks. It is far better to have more blanks and to distribute the work of reporting, for it not only simplifies the blanks, but, by giving each foreman less to report, greater accuracy is secured. In fact, there are many operations that can best be reported by the workmen themselves. Thus, to continue the illustration of the macadam road work,

each of the teamsters hauling broken stone should carry an individual report card which is punched or marked by workmen at each end of the trip.

We have said that the pay items should be analyzed according to the operation involved, but care must be taken not to select operations upon which men are engaged for but a few moments continuously. To illustrate: In mixing concrete by hand, there are usually the following operations—(*a*) loading wheelbarrows, (*b*) wheeling, (*c*) mixing, (*d*) loading, (*e*) transporting, (*f*) spreading and ramming. Some gangs are so organized that a few men are kept constantly busy loading wheelbarrows with sand and stone, while the rest of the gang spends a few minutes wheeling, a few more mixing, and so on. Clearly it would be foolish to subdivide the operations on the report cards where the organization is of this character, for most of the men are changing their operations so frequently that a foreman would have time for doing nothing but to record their changes.

We see that the designer of a report blank should know approximately what the organization of the gang and what the methods of operation are to be, before he can design a report blank that will be concise, and complete, but with no superfluous headings. Since there are almost innumerable methods of doing work, it is obviously impossible to furnish a set of printed report cards that will exactly serve all cases, unless the classification headings used are very general. However, the designing of a report card is a comparatively simple matter once the organization and methods of doing the work are known, provided the foregoing system is used.

A tentative report blank can be designed either by using some existing report card for similar work as a guide, or by referring to some book that gives, in detail, the costs of construction work similar to that for which the report blank is intended. From the items of cost given in published records, a classification can be prepared that will be of decided help in planning the report card.

In order to economize space on a report blank, it is not always necessary to print the classes or subclasses in full. Abbreviations and key letters may be used. Sometimes the mere recording of the rate of wages opposite a class will show the subclass. Thus, under the class of "Forms" (building wooden

forms for concrete) if a wage of 40 cts. per hour appears, also a wage of 70 cts. per hour, it will be understood that the latter refers to the carpenter, while the former refers to the carpenter's helper.

Having decided upon the classification of operations and employees, the next thing to determine is the character of the performance report, which is usually to be recorded on the same card.

In Chapter IV we have discussed the difficulties of reporting daily performance, and have indicated ways of overcoming the difficulties. It is evident that a foreman or timekeeper should not be expected to report the number of units of each class of work performed if any considerable amount of difficult measurement is involved. Hence, it is usually futile to provide for a daily report of the number of cubic yards of earth excavated. On the other hand, the number of wagon loads, or car loads, may usually be reported, and the blank used for excavation should usually provide for such a report.

If some of the excavated material is shoveled directly into the embankment or hauled by scrapers, while some is hauled by wagons, it will be futile to provide for a daily report of loads hauled. In such cases, it is often advisable to report merely the number of lineal feet of work done daily. Thus, in road work, where the excavation is shallow and mostly from ditches, the report should show the station and plus up to which the grading is completed at the end of the day. It is then the function of the office force to determine the yardage from the office records.

The amount of concrete and cement work of all kinds can be reported with considerable accuracy by stating the number of bags of cement used during the day.

Chapter IV should be consulted for further hints on methods of measuring daily performance of gangs.

The amount of supplies, like coal, used each day, can usually be reported if some system be devised for recording consumption or for readily inventorying the stock on hand each night. It is generally wise to require coal to be measured in boxes or in wheelbarrows of uniform size, uniformly filled. Then each fireman reports the number of cubic feet (or boxes) of coal used during the day.

Empty dynamite boxes are often convenient for purposes of measurement, as they hold exactly ¾ cu. ft. each.

Individual Record Cards.—Wherever individual workmen are paid by the bonus or piece rate systems, it is usually best to provide a separate record card for each workman, for it is difficult to make a compact record on one card that will show not only the occupations of a number of men, but the performance of each man. This is particularly true where the men are repeatedly shifted from one class of work to another.

Where one man operates a machine, like a rock drill, it is usually wise to provide him with his own individual record card, upon which he is required to record his day's performance. A modification of this plan is to let the foreman carry the individual records of all the men, and fill in each card himself.

The engineman on a dinky locomotive should be required to make and fill in a daily report, showing the number of train loads hauled, time lost, etc., as shown on page 301.

A teamster should usually be required to carry a card whereon are recorded the times of arrival or departure at each end of each trip.

A steam roller engineman should be required to fill in a card report showing number of lineal feet of road rolled, and the number of miles travelled by the roller. The latter should be recorded by an odometer.

Kinds of Punches to Use.—If punch card reports are to be used, an ordinary conductor's punch will serve for small cards; but it is generally desirable to have large cards, which necessitates the use of a special punch having a 2-in. reach. Such special punches are made by L. A. Sayre & Co., of Newark, N. J., and by other railroad supply concerns.

Size and Kind of Daily Report Cards.—It is usually desirable to have report cards of a size that will be suitable for filing in the standard card index files. A size that will be found satisfactory for general use is 5 by 7¾ in.

If reports are to be written and made out in duplicate, the report cards should be made up in pads of alternate thin and thick cards, so that a carbon paper may be inserted between a thin card and a thick one.

It is generally wise to have cards tinted one color for the original and another color for the duplicate. It is also a good plan to designate the kind of report card by a key letter, or combination of letters, which may be stamped in red in one corner of the card. Thus the letter T may be used to designate the

daily report card of teamsters. Instead of using mnemonic key letters, some contractors prefer to use different tints for different classes of report cards.

This works well when there are only a few classes, but becomes confusing when there are many, and is worthless as a means of distinguishing cards at a glance when there are very many classes.

Where a great deal of information must be crowded on one card, it is often desirable to provide for writing the report on both faces of the card. This is objectionable, however, because it makes it impracticable to produce a duplicate by the use of carbon paper. It is also inconvenient to examine such a card after it is placed in a filing case.

Foreman's Diary.—The foreman or the superintendent should always be required to keep a daily diary in which should be entered:

1. Verbal orders received from engineers and owners.
2. Verbal requests made to the engineers for grade stakes, etc.
3. Weather conditions.
4. Remarks as to hardness of digging, poor quality of materials and supplies, slowness of their delivery, general inefficiency of the men available, and such other conditions as bear upon the economic performance of the work but can not be shown in the daily report.

The ordinary field foreman will not keep a diary of much value unless its pages are inspected daily. This requires that it shall be a duplicate loose leaf diary, the original leaf being sent to the office with the daily cost report, and the duplicate, or carbon copy, being retained by the foreman and bound in a loose leaf binder.

Designing Punch Card Reports.—We have already enumerated the advantages of the punch card for certain kinds of daily reports. One of the earliest punch cards devised for this purpose is shown in Fig. 4, and was designed by one of the authors for recording the daily work done by each team in hauling broken stone for macadam. Each teamster carries a card which he presents for punching at each end of the trip. The diamond punch hole indicates that the loaded team left the crusher bin at 7:05 A.M. The cross punch hole shows that it dumped its load on the road at 8:20 A.M. A new card is issued to each teamster each day; but, if it is desired to provide one card that will serve for a full week, one may be easily designed.

Figure 5 is such a team card of macadam road work. The punches on this card show:

1. That the team was No. 14.
2. That its pay was 35 cts. per hour.
3. That the record is for the week ending July 12.
4. That the team was hauling 2½-in. stone for macadam.
5. That the haul was from Station 124 to Station 185.
6. That the first trip on Monday was begun at 7:05 A.M. and that the team reached the place where the stone was dumped at 7:30 A.M.

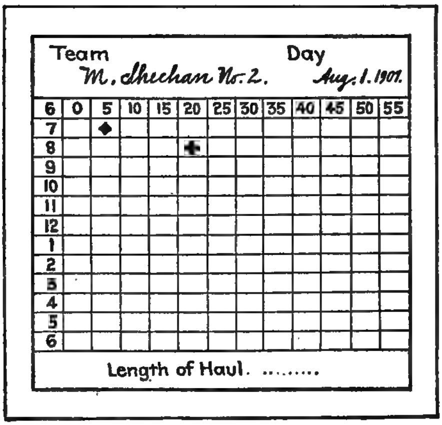


FIG. 4.—Punch card, team.

A more elaborate form of individual punch card is shown in Fig. 6 and is designed to show the daily performance of each rock drill in great detail.

The punch holes in this particular card show:

1. That the holes were spaced 4 ft. one way and 5 ft. the other.
2. That + bits were used.
3. That the drill was in good condition.
4. That the drill was No. 2.
5. That a 3 in. starting bit was used.
6. That 54 ft. of hole were drilled.
7. That there were 4 holes, Nos. 1, 2, 3 and 4, whose depths were 15, 14, 13 and 12 ft. respectively.

(Note: A hole, No. 0, is provided, in case a partly drilled hole of the previous day has to be completed, for, in that event,

the number of feet drilled to complete the hole is punched above hole No. 0.)

7. That the date was July 16.

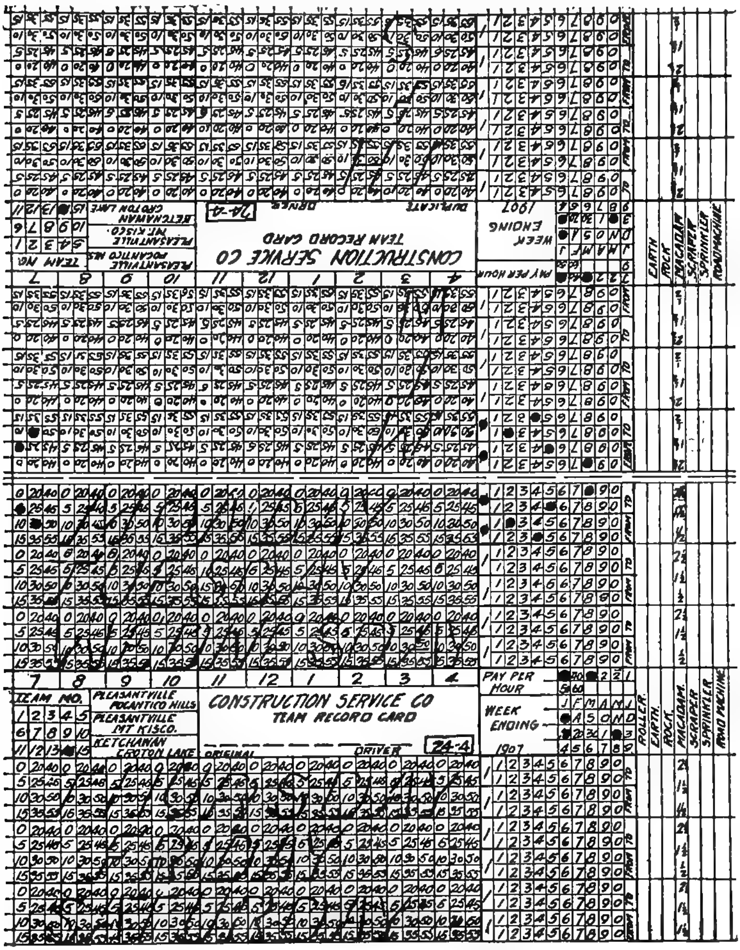


FIG. 5.—Duplicate punch card, teaming (original size 5 × 7¾ in.).

8. That work began at 7:02 A.M., and hole No. 1 was completed at 9:44; that work was stopped at 12 A.M. and begun again at 1:00 P.M.; that hole No. 2 was finished at 1:18 P.M., hole No. 3 at 2:36, hole No. 4 at 4:52.

It is not usually necessary to record rock drill operations to the nearest even minute, as the nearest 5 min. will ordinarily suffice; but it is sometimes desirable to have the drillers record

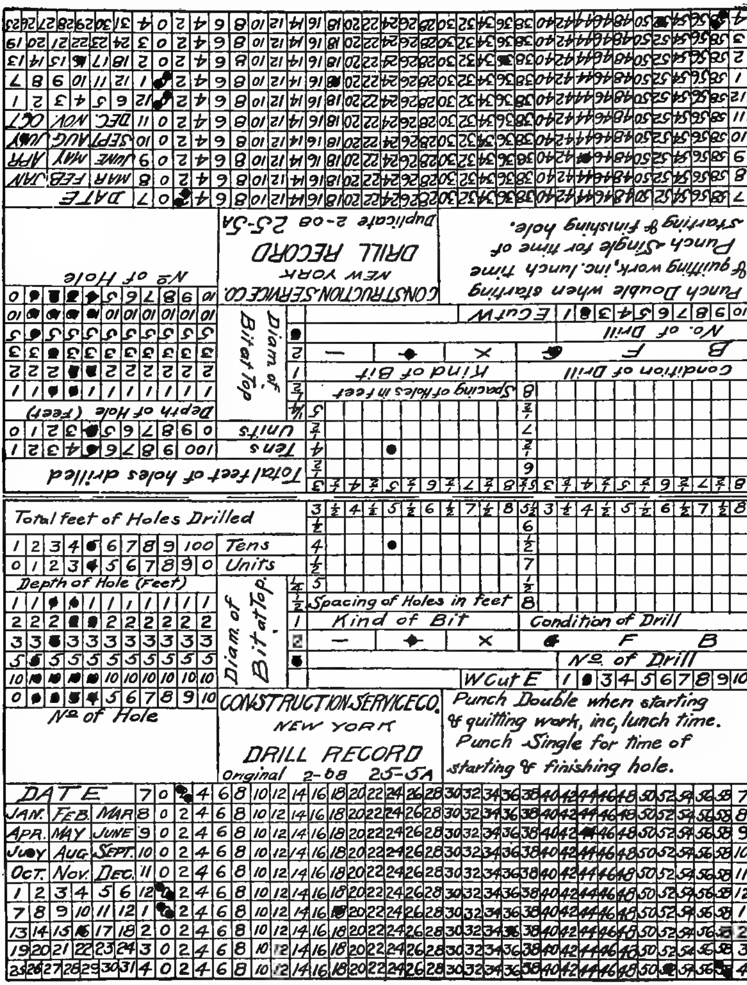


FIG. 6.—Duplicate punch card, drilling.

the time of starting one hole and of starting the next hole. In that case this card, which provides for a time record on 2 min. intervals, is more satisfactory than one designed for 5 min. inter-

vals. Drillers are often very slow in shifting drills from one hole to the next, which is well shown up if the time of finishing one hole and of starting the next is punched. Punching two holes in the card in one square (punching double), can be used to indicate time of starting a hole, while punching one hole indicates its time of completion.

Note that in designing punch cards, space can be economized by the arrangement shown in the upper left hand corner of Fig. 6, where the upper line indicates "tens" and the lower line indicates "units."

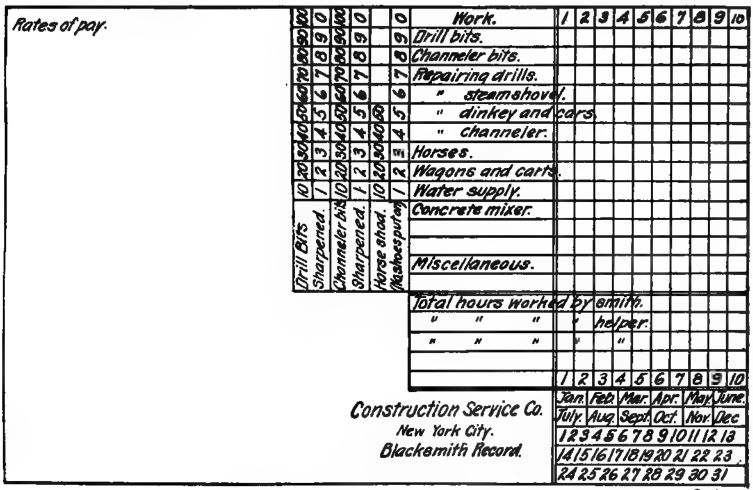


FIG. 7.—Punch card, blacksmith.

The punch card lends itself well to recording the work done by individual men, or by one skilled man assisted by a few helpers, as exemplified in the blacksmith report card, Fig. 7. Here, it will be seen, the blacksmith punches the number of hours spent at each class of work. The nearest half hour is designated by punching on the line between the two full hours. By punching a blank card for every bit sharpened, the smith keeps tally of the number sharpened, and, at the end of the day, punches the number on this report card.

On some classes of work, particularly shop work, it is often desirable to have a separate punch card for each class of work,

instead of recording several classes of work on the same card. Figure 8 illustrates such a card that has been used by the National Switch & Signal Co. and was described by Mr. Chas. Hansel and published in the "Complete Cost Keeper," 1903. Each workman perforates the 5-min. time card for each job on which he is employed, simply piercing the card at the 5-min. points most nearly representing his times of beginning and ending work on the job in hand, the appropriate order number being

TIME CARD

Workman's No........ Date...........

Date Commenced ....

Order No.......................

Catalog No.....................

Number Pieces ....

Operation No..................

Date Finished..................

H	Min.										
7	5	10	15	20	25	30	35	40	45	50	55
8	5	10	15	20	25	30	35	40	45	50	55
9	5	10	15	20	25	30	35	40	45	50	55
10	5	10	15	20	25	30	35	40	45	50	55
11	5	10	15	20	25	30	35	40	45	50	55
12	5	10	15	20	25	30	35	40	45	50	55
1	5	10	15	20	25	30	35	40	45	50	55
2	5	10	15	20	25	30	35	40	45	50	55
3	5	10	15	20	25	30	35	40	45	50	55
4	5	10	15	20	25	30	35	40	45	50	55
5	5	10	15	20	25	30	35	40	45	50	55
6	5	10	15	20	25	30	35	40	45	50	55

Approved

............................Foreman

FIG. 8.—Punch card, shop work.

entered on the card by the foreman. When the workman enters the shop in the morning, he is furnished with one time card, which he hangs on the upper hook of his individual time board, after perforating it at his beginning time. If the foreman gives the workman a second job before the first is completed, he fills in the order number on a second card, and hangs this second card on the upper hook. Thus the workman may have any number of jobs before him, each order being given on a separate card. When any job is completed its card is transferred to the lower hook. The time cards on the lower hook are removed by the timekeeper each morning, cards on the upper hook being left undisturbed.

Punch Card Showing Time and Occupation of Each Member of a Gang.—It is frequently desirable to record the amount of time spent by each member of a gang on each kind of work performed by him. Some ingenuity is required to design a punch card for this purpose, without making the card too large. Figure 9 shows a punch card (for a rock channeling gang) that provides for 17 men in a gang with 10 different occupations. The names or numbers of each of the men are written in the center of the card, with their rates of wages. All the rest of the data is punched.

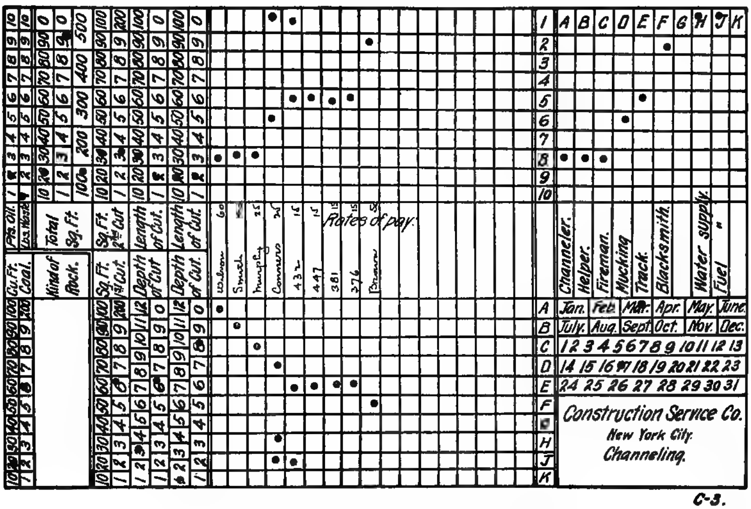


Fig. 9.—Punch card, rock channeling.

It will be noted that Wilson, Smith and Murphy each has one punch mark above his name, and to the left of the figure 9. This shows that each of them worked 8 hr.; but at what class of work? At the right of the figure 8 are three punch marks, under *A*, *B* and *C*, indicating channeler, helper and fireman. Which of these three men is the channeler? To find out, drop down to the lower half of the card, where the key letters *A*, *B*, *C*, etc., are found in a vertical column. Running the eye along the horizontal line from *A* to the left, we find a punch mark directly under Wilson's name, which shows that he is the channeler. In like manner, the punch mark under Smith's name, and to the left of *B*, shows that he is the helper.

The fourth man, Connors, has two punch marks over his name, one opposite 6, and one opposite 1. To the right of 6 we find a punch hole under *D*, which is in the column marked mucking; and, since there are no other punch holes opposite 6 and over the names of other men, it is clear that Connors spent 6 hr. mucking. But it is not so clear at first glance what the punch hole above Connor's name to the left of the 1 means, for we find two punch holes to the right of 1, through *H* and *J*, indicating work in connection with water supply and fuel supply. On which of these classes of work did Connors spend the 1 hr.? Dropping down to the vertical column of key letters, let the eye travel along the line to the left of *H* until it comes under Connors' name; there we find a punch hole indicating that he worked 1 hr. on water supply. But we see still another punch hole below Connors' name and to the left of *J*; hence he worked another hour on fuel supply. This makes the total of 8 hr. for Connors.

The men whose numbers are 432, 447, 381 and 376 each worked 5 hr. at track laying; but man 432 has a second punch mark over his name, to the left of 1; we find what this 1 hr. of work was by looking for the punch marks below this man's number (432); for there we see that in addition to his having a punch mark to the left of *E*, which relates to his 5 hr. on track work, he has also a punch mark to the left of *J*, which relates to his 1 hr. spent on fuel supply work.

This same scheme of indicating each man's work and the time spent upon it is susceptible of wide application, as will be seen by referring to the report cards in Chapters IX and X.

In addition to the record of time spent by each man on the different classes of work, the card in Fig. 9 shows:

1. That day was March 17.
2. That 26 cu. ft. of coal were used by the channeling machine.
3. That 2 pt. of oil and 1 lb. of waste were used.
4. That the length of the first cut was 32 ft. and its depth 36 in.
5. That the length of the second cut was 22 ft. and the depth 18 in.
6. That the area of the second cut was 96 sq. ft., and that of the second cut was 33 ft.
7. That the total area was 129 sq. ft.

While the description of such punch cards sounds complicated, experience has demonstrated that any foreman or intelligent workman is easily taught how to use them.

The important thing to impress upon the man who is to make out the report is that every workman must have at least one punch mark above his name and one below it, and that there must be a third punch mark on the line to the right of the upper punch mark and directly under the key letter which shows the nature of the work done, and that the punch mark below the man's name must be on the line to the left of the same key letter —the three punch marks showing the time spent and the kind of work.

Duplicate Punch Cards.—It is often desirable to have a duplicate record of the daily report, one copy of which is sent to the office and the other retained by the man who makes the report. This is easily done with a punch card designed as shown in Fig. 10 so that, when folded along the center line, the duplicate half comes exactly below the original half.

The maintenance of way card, Fig. 10 shows the number of men employed on the various classes of work indicated, the time spent on each, and the location of each class of work. The first column of figures indicates hundreds, second column tens, and third column units, so that 999 is the largest number that can be punched.

The particular card illustrated gives the following information:

The work consisted of renewing ties and surfacing track and was located between telegraph poles 121 and 990. There were 10 ties renewed and 260 ft. track surfaced, and 2 hr. were spent in traveling. There was a total of six men employed. All worked 1 hr. on *D* (renewing ties), all spent 2 hr. traveling, and all spent 7 hr. on *F* (surfacing track). Thus the work was distributed over *D*, *F*, *K*, as shown in the lower right hand corner, and all six men worked on each item. At this place is also shown the rates of pay. All the laborers received 14 cts. an hour and the foreman received $50 per month. The date was May 21, and the foreman's name was Applin.

It will be noted that while the original card will show clearly the number of units of work done, etc., the duplicate, which is retained for an official copy and is not much used, must be read backward.

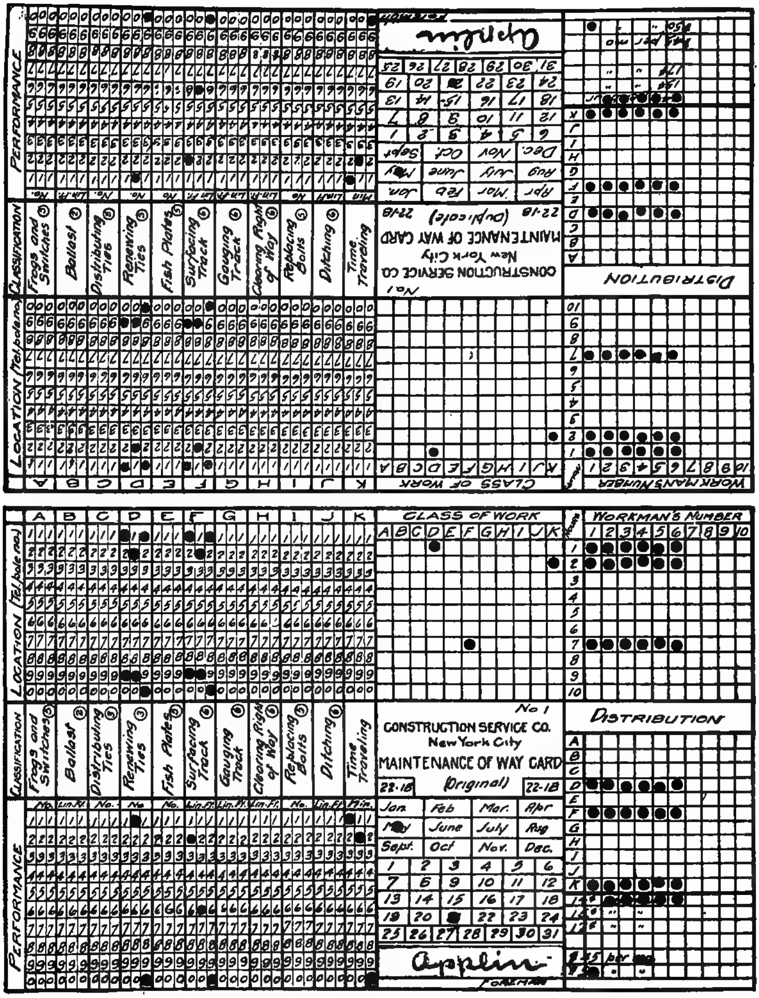


FIG. 10.—Duplicate punch card, maintenance of way.

Record Cards Accompanying Each Piece of Work.—In doing machine shop work, it is often necessary to have one piece of metal pass through the hands of several workers. For example, one man may drill holes of a certain size, another may drill holes of another size, still another may thread the holes, and so on. In such a case a record card may be attached to, or accompany each piece or lot of pieces. In blanks provided on the card, each worker enters his number and the amount of time spent in doing a specified kind and amount of work on the piece.

Using Several Record Cards, One for Each Piece of Work.—A method that is usually preferable to the one just described for shop work, is to give each workman several record cards. As each new piece of work comes to him, he enters its "order number" on a record card, and records the time he spends on the piece. When finished, he uses another record card for the next piece. Figure 8 shows a punch card designed for this sort of record.

Store Keeper's Reports.—The store keeper's duties include the following:

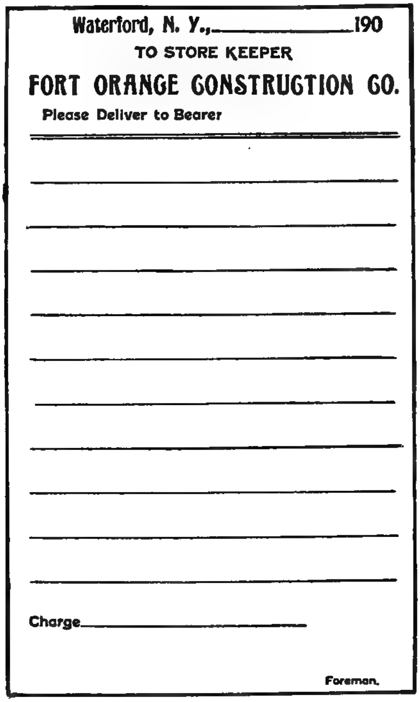
1. He must receipt for and take charge of all material delivered for temporary storage.
2. He must see that all of this material is properly accounted for and none lost or stolen.
3. He must take charge of the issuing of materials and supplies to the men and see that they are issued in proper quantity and that there is no waste.
4. He should see that needed material and supplies are issued without loss of time.

To accomplish these objects it is necessary that some one be on hand at the store house at all times when material is likely to be delivered or called for. This includes the noon hour as well as other times. Considerable economy results from sending to the store house in the noon hour to obtain articles that are needed in the afternoon.

The second duty of the store keeper is often interfered with by men going to the store house for articles needed in a hurry and not leaving receipts for them. The only way then that the store keeper can account for his materials would be by periodical inventories, and then at the best there is nothing whereby the periodical inventory can be checked. The perfunctory inventory is generally useless. All the men in the field in the position of

authority or who are likely to require to have materials issued to them should be provided with small requisition blanks similar to the one shown in Fig. 11, and the store keeper should require a requisition slip as a receipt for all material issued.

At the end of the month these receipts for material issued should tally with his inventory and list of material received.



Waterford, N. Y., ______ 190

TO STORE KEEPER

FORT ORANGE CONSTRUCTION CO.

Please Deliver to Bearer

Charge ______

Foreman.

FIG. 11.—Requisition slip.

On some work it is customary for the store keeper to go around the job interviewing the different men who may need material and take charge of getting the material to them, taking a receipt for material from the messenger. These receipts then form part of the record. Another way is for the foreman of each gang every night to turn in with his report a statement of the material that he will need and when. The requisition part of the report can then be abstracted and turned over to the store keeper. This latter plan has the objection that, unless somebody works

over-time, it is difficult for the store keeper to get the material as early as it is likely to be wanted. The rule of requiring receipts for material should be applied even to such large units as piles and timber generally. Although it seems at first glance an easy matter to keep track of such large units without the application of any particular system, it is found exceedingly difficult in practice.

After material and supplies have been issued by the store keeper they may remain upon the work for some time before being actually used. This applies particularly to such material as dynamite that is kept in magazines. The key of the magazine should be in charge of one man who should record the number of cases that he removes during the day. One of the best methods of getting this record is to have a card hanging by the magazine door and require the magazine tender to puneh a holc in the card for every case of powder that he moves. This card can then be turned in to the store keeper each day, from which the records of powder used and powder on hand can be kept posted. The same method works very well for recording cement.

In general, when the material records are made by productive laborers in the field they should be made to the store keeper and be checked and handed out by him.

When no definite rule is established for the prompt obtaining of material on request the inability to obtain material promptly is used as a most prolific excuse for not getting work done. In a certain case in point some important work was delayed for a long time because a pump gasket blew out just after the requisition rule had been instituted on the work and before the store keeper realized the necessity of promptness in making deliveries or the directness of his responsibility.

Reports on Materials and Supplies.—Figure 12 shows a requisition blank for materials, which is self explanatory.

Figure 13 is a card for reporting supplies received. It includes the oil, waste, powder, caps and fuse supplied to the various field organizations, such as drillers, pumps, various steam shovels, dinkeys, cars, shovels, and also shows the amount remaining on hand. This is for steam shovel work in rock.

Figure 14 is a material card designed to be used daily by the foreman on concrete work for recording the materials received. The size of various loads of cement, gravel, sand, screenings,

No. 50 DANSVILLE AND MT. MORRIS R. R. MATERIAL

A. S. MURRAY, JR., RECEIVER

REQUISITION ORDER DANSVILLE, N. Y., ... 19

TO ....

....

PLEASE FURNISH THE FOLLOWING MATERIALS

....

DELIVER VIA. ....

D. L. & W. R. R. DELIVERY NOT ACCEPTED

APPROVED

.... GEN. SUPT.

Keep white copy in Dansville Office, mail others to Gen Mgr's Office. Blue slip is dealer's order for material.

FIG. 12.—Requisition blank.

SUPPLY REPORT NO. 1. ....190....

	Drillers.	Pumps.	No. 1 Shovel.	No. 2 Shovel.	No. 1 Dinkey.	No. 2 Dinkey.	No. 3 Dinkey.	Cars.	Shop.	Little Hill.	On Hand.
Cyl. Oil....											
Eng. "											
Blk. "											
Waste											
Powder....											
Dynamite.											
Exploders.											
Caps.......											
Fuse.......											

FIG. 13.—Blank for reporting supplies received.

stone, and the number of feet board measure of lumber are shown on one half of the card, and on the other half are the amounts of glass, steel, lampblack, oakum, nails, etc. On the back of the card an entry is supposed to be made of all material sent away from the shop or remaining on the work at night, thus giving a check upon the quantity of materials used.

Job No. MATERIALS RECEIVED

Date 190 Foreman

Size or Brand		From Whom Received	Size or Brand		From Whom Received
bbls.	Cement		bbls.	Glass	
bags	"		bars	Steel	
lds.	Gravel		"	"	
"	Sand		"	"	
"	Screenings		"	"	
lbs.	Stone		lbs.	Lampblack	
"	"		"	Oakum	
lds.	Sand		"	Nails	
ft.	Lumber				

FIG. 14.—Blank for reporting materials received.

Checking the Accuracy of Reports.—Systematic checking of the accuracy of reports made by individuals or foremen is of paramount importance, for, unless this is done, there is apt to be gross falsification of the reports in order to make a favorable showing of performance. Thus, if a drill runner is not checked occasionally as to his report of number of feet drilled, he is apt to add several feet to his actual performance.

On one railway with which the authors are familiar, the master mechanic is in the habit of reporting the time of men spent in building new cars as if it were spent in repairing old cars. The object in doing this is to make a creditable showing of the cost of making new equipment. While it is true that this seems like robbing Peter to pay Paul, it must be remembered that there is usually great difficulty in determining just what is a reasonable cost of repairing a car, whereas there is no difficulty in fixing upon a reasonable cost of making a new car.

So many men are dishonest, particularly in ways that are

not actually criminal, that implicit trust should not be placed in reports that are not verified by systematic investigation at unexpected intervals of time, if they are not subject to constant checking.

On construction work it should be the duty of some one to make reports that will check the reports made by individual workmen and by foremen. The time keeper is usually the man upon whom part of this checking devolves. Thus, the time keeper may be required to make certain measurements at the close of the day, from which a foreman's report of performance can be checked, as, for example, the number of drill holes and the depth of each. The timekeeper may also be required to visit each part of the work frequently, noting the number of men engaged in each class of work at the time of each visit. Frequent visits are often made possible by providing the timekeeper with a horse or a motorcycle.

Checking the distribution of the men of a gang, as well as observing the energy with which they are working, may frequently be done to advantage by means of a telescope or field glasses in the hands of an observer located in a tower or on some high point of ground.

By requiring different foremen and different individuals to report on the same performance, an excellent check can often be secured. Thus, a dinkey locomotive engineman should report the number of trains hauled, and either the dump foreman or the steam shovel engineman should render a similar report.

The monthly estimates of engineers should, of course, be used to check the daily reports of foremen, as far as possible; and on large jobs it is often desirable for a contractor to employ engineers to cross-section and measure the work once a week, if not more frequently.

Where the gang under a foreman is frequently shifted from one class of work to another, the foreman should always record the time that the change is made, in one of the ways already indicated. When this is done, the superintendent or walking boss should examine the foreman's record occasionally, during the day—not necessarily every day—to assure himself that the foreman is posting the record properly and at the time each change is made.

There should always be some system of recording the receipt

of daily reports at the office. This is sometimes effected by having a tabular list of all the reports that should be received, and by placing a check mark opposite the name of each report (or each foreman or individual making the report) under the day of the month to which the report relates. A glance at such a tabulation shows whether any report is missing.

If it is the practice to plot or chart the returns shown by each report daily, then no further check may be needed to show that the report has been received.

One of the advantages gained by divorcing cost keeping from bookkeeping is the check thus obtainable on both. The aggregate weekly pay roll shown by the timekeeper's report should check fairly well—not necessarily with great precision—with the aggregate pay roll deduced from the foreman's reports. Incidentally this check makes it more difficult for a timekeeper to "pad the pay roll:" that is, to enter fictitious names upon the pay roll or to credit a man with more time than he is entitled to. Many a contractor has been robbed in this manner.

If the distribution of costs shown on the books corresponds with the distribution derived from the daily report cards, a fairly close check is obtainable.

It is generally wise to have accounts for each of the main items of materials and supplies, such as lumber, cement, coal, explosives, etc. Then the total consumption of coal, for example, as deduced from the foremen's daily cost reports, should check fairly well with the amount purchased, as recorded by the bookkeeper. Likewise the bookkeeper may divide the payroll into certain general classes of labor and assign an account for each class which should check with the cost records turned in by the foremen. But, in our opinion, it is a serious mistake to encumber the bookkeeper with a multiplicity of accounts intended either to show detailed costs or to check the various details of cost deduced from the daily cost reports.

Cost Charts.—For showing relative performance or relative unit costs, no method is so satisfactory as a diagram or chart. A glance at the unit cost line plotted on a chart shows the manager whether there is cause for congratulation or alarm. The up and down waves of a cost line are far more impressive than columns of figures ever are.

A chart of daily performance has the incidental advantage of affording an automatic check as to whether all the daily cost

reports have been turned in or not, for without the reports the lines on the chart can not be plotted.

The chart shown in Fig. 15 was 8½ by 11 in.—a large enough size to show the unit costs with sufficient accuracy for comparative purposes.

It will be noted that three lines are plotted on the chart. The upper line, drawn in full, marked *A*, shows the total daily yardage of rock loaded by two steam shovels. The line *C* shows the cost per cubic yard. The line *B* shows the total daily operating expense, including only the pay roll and not the cost of fuel, dynamite and other supplies.

The unit cost line, *C*, is the only one that presents any difficulty in plotting. On most contract work, some of the men are paid by the month, and their wages go on whether it rains or shines. The number of working days in the month (excluding Sundays and holidays) divided into the total monthly pay roll of these "steady pay" or "monthly pay" men gives the daily payroll of the "monthly pay" men, to which must be added the pay roll of the men who work by the hour or by the day. On days when the weather is so bad that no work at all is done, the daily pay roll of the "monthly pay" men would be divided by nothing, which gives an infinite unit cost, and therefore can not be plotted. But, if it is not plotted, and if there are several days in succession on which no work is done, the unit cost line ceases to show the true unit cost. This difficulty, however, is more imaginary than real, for the object of the chart of daily costs is not to show whether a profit is being made, but to show how well the work is being managed on those days when the weather is such as to permit any work to be done.

In plotting a chart of costs, the performance can be plotted, on charting paper, each day in pencil and can be inked in at the end of the week, blueprinted and as many copies as desired sent to the home office.

Referring to Fig. 15, we see that conditions of weather, accidents, etc., can be recorded on the chart. The full history of the work shown by this chart is as follows:

The shovels did not work on the 1st or 2nd of the month, but one shovel started on the 3rd, making a record of 780 yd., which was the highest point that had been reached for several months. The cost of operation of both shovels was $240, making a unit cost for the output of one 38 cts. On the next day the

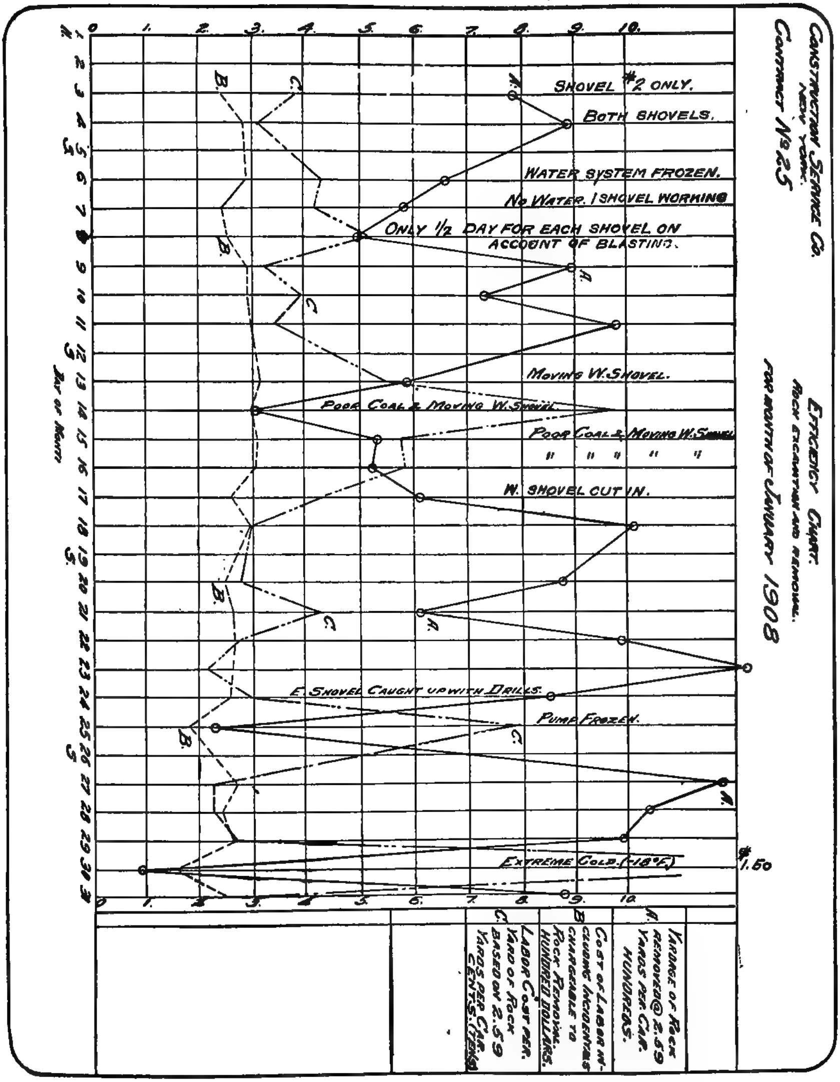


FIG. 15.—Efficiency chart, rock excavation.

other shovel worked, but the total output of both was only 885 yd., and, while the total cost rose to $285, the unit cost dropped to 31½ cts. On the 5th of the month, being Sunday, no work was done. On the 6th the work was badly interfered with, because the water pipe, which supplied water to the work, was frozen, and the output of the shovels fell to 660 yd., while the total cost was raised slightly to $290, making a much higher unit cost of 43½ cts. On the 7th one shovel worked in a crippled condition for the whole day, while the other worked only a half day because of the short supply of water. The performance dropped still further to 580 yd., on account of the fact that one entire pit and dump crew was laid off for half a day, and the unit cost fell to 42 cts. On the 8th both shovels were held up for nearly half a day because of poor blasting in front of them and the necessity of drilling and blasting in the shovel pits. Because of the likelihood of starting at any time the crew could not be laid off, so the total expense was kept up to about $260, making the unit cost jump to 51½ cts. On the 9th both shovels were working in good shape and produced an output of 890 yd. with a complementary reduction in unit cost, since the total labor cost was increased but little. On the 10th the performance dropped slightly, but on the 11th it again rose, reaching 975 yd. The total labor cost for this day was higher than it had been any time during the month, while the unit cost was about 34½ cts. The 12th was Sunday and no work was done, and on the 13th but one shovel was working, as the other shovel was moving back in the cut. The high total labor cost maintained caused a very steep rise in the unit cost line. On the 14th one shovel was still moving back while the work of the other shovel was badly delayed because of trouble with poor coal both on the shovel and on the dinkey locomotives hauling dump trains. This difficulty was overcome to some extent on the 15th and 16th, but the output was still very low even for one shovel. On the 17th the second shovel cut in, but owing to a very shallow cut and frequent moves necessary, a very small output was obtained. The next day, however, both shovels were working well and got out 1,020 yd. The 19th was Sunday. On the 20th the output was maintained at rather a high figure, being 875 yd.; on the 21st the output dropped because of rain;[1] rose again on the 22d and went still

[1] Weather and some other conditions mentioned here are not shown, but are mentioned by way of explanation.

higher on the 23rd, reaching on that day 1,230 yd., which was the highest daily output of the month, and on that day the lowest unit cost is also shown. On the 24th the output fell because one shovel was delayed by having to wait for drilling, and on the 25th only 230 yd. were taken out because neither shovel worked more than a few hours because the water supply was shut off by the freezing up of the pumping station. The 26th was Sunday and no work was done, but on the 27th the output jumped to a high point, reaching 1,180 yd., and the unit cost fell to 23½ cts. The next day the output was 130 yd. less, but the total labor cost was also much less and the unit cost was maintained at 23½ cts. The performance fell a little lower on the 29th, but was still well above the average, but on the 30th fell to less than 100 yd. because the weather was so extremely cold (minus 18°F.) that the men could not work. In this case the fixed charges of the shovel raised the unit cost of the 90 yd. taken out to about $1.50. When work was resumed on the 30th 875 yd. were removed at a cost of 30 cts. a yard. The jagged nature of the lines on this chart is due to the character of the weather. It will be noted that the general trend of the unit cost line was downward.

The channeler chart, Fig. 16, shows only the performance and unit cost of the work done. This record is also for the month of January. Work began on the 2nd, the performance being but 160 ft. of channeling done by two crews. The performance fell from that point to 85 ft. on the 5th and rose to 185 ft. on the 6th and again fell and remained low until the 9th. These bad records were due to the presence of nigger heads in the rock being channeled which made fast work absolutely impossible. On the 9th the performance rose to 160 ft. and kept on increasing until the 11th, when 200 ft. was reached. On the 13th, 14th, 15th and 16th the performance was low because of poor track. The track was fixed by the 17th, when performance again rose and was maintained at a figure slightly above the average until the 24th, when, because of the extreme cold one crew deserted its post and allowed the pipes feeding the machine to freeze. On the 29th the performance fell slightly, due to the clogging of the channeler by earth sliding into the cut, and the unit rose because it was necessary to put on an extra force to clean out this earth. On the 30th but little work was done owing to the extreme cold, but on the 31st the high record of the month was made, 370 ft. being channeled.

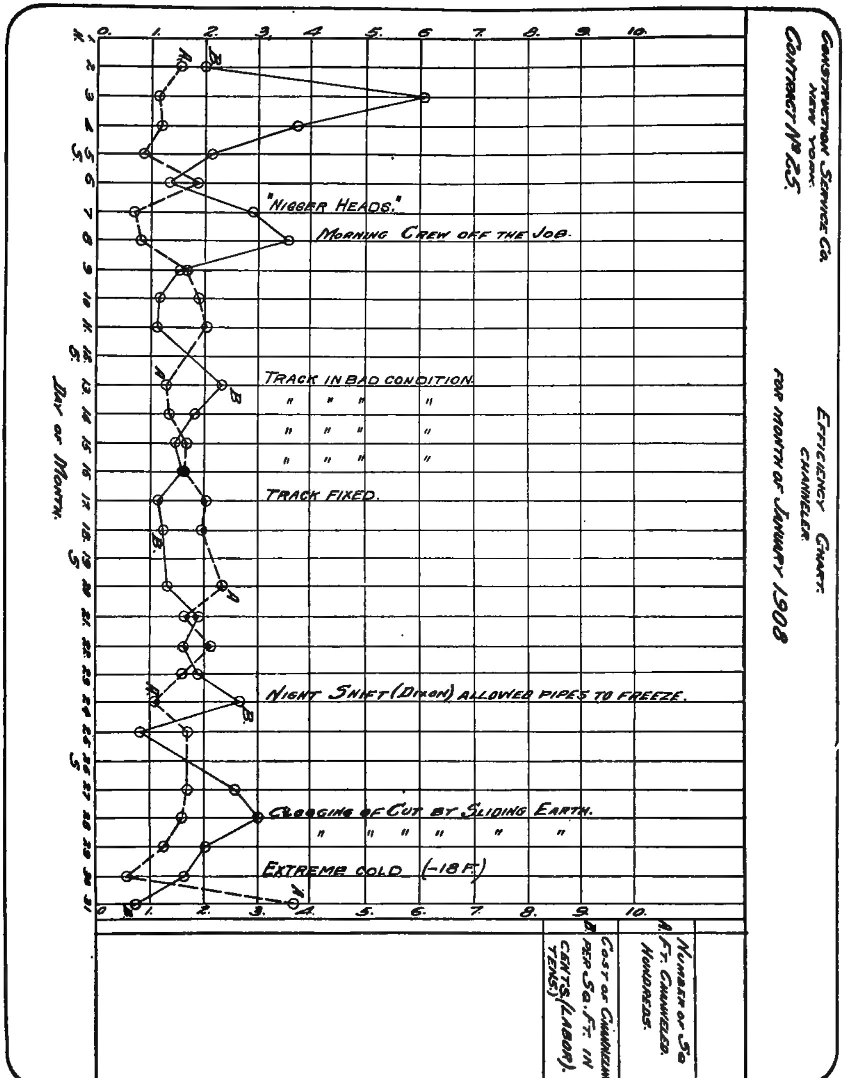


FIG. 16.—Efficiency chart, rock channeling.

Progress Charts.—It is generally desirable to record graphically progress the of each particular class of work on a contract. This is best done by means of a progress chart similar to that shown in Fig. 17, which is a modified form of the chart shown on page 333.

This chart relates to excavation. The first column is a percentage column. The second column gives the length of the excavation (trench, ditch, or the like). The third column gives the number of cubic yards. The fourth column gives the estimated cost. The fifth column gives the actual cost; a sixth column of actual cost is provided in case it overruns the estimated cost. The total length of the excavation to be done is 775 ft., which is written opposite the 100%. Then the length column is divided into 7¾ parts, each representing 100 ft., or a "station."

The total yardage in this length of 775 ft. is 1,600 cu. yd., which is also written opposite the 100%. Then this yardage column is divided into 16 parts, each representing 100 cu. yd. The work has been estimated to cost 50 cts. per cubic yard, therefore the total cost of the 1,600 cu. yd. should be $800, which is written opposite the 100%; and the estimated cost column is divided into 8 parts, each representing $100.

This work on section of excavation is scheduled to begin June 3, as indicated in the space to the left of the percentage column and at the bottom; and it is scheduled to be finished in 3 weeks, as indicated.

The work is begun on schedule time. June 3, as indicated by the entry to the right of the last column, and at the end of the first week (beginning of the next), June 10, the progress and cost are shown by the hatched portion below the heavy black line. It will be seen that the excavation has been completed to station 1 + 50 (= 150 ft.), as shown in the second column; and that 350 cu. yd. have been excavated, as shown in the next column. The estimated cost of the 350 cu. yd. is $175, as shown in the fourth column. The actual cost has been proved to be the same as the estimated cost, or $175, as shown in the fifth column. The yardage completed up to June 10 is 22% of the total, as seen by comparing the first, or percentage, column with the third, or yardage, column; whereas, to have lived up to the estimated schedule, 33% of the yardage should have been excavated by June 10.

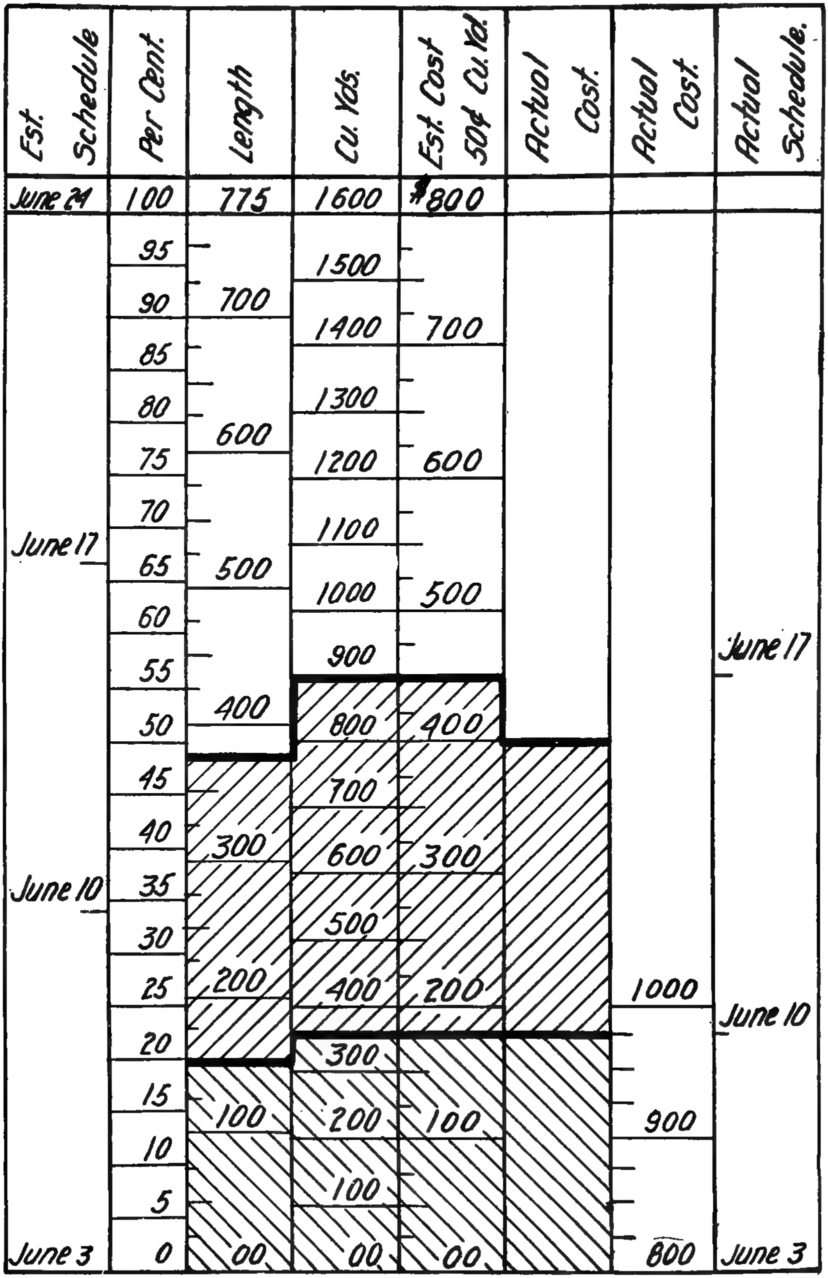


FIG. 17.—Progress and cost chart, trench excavation.

The performance of the next week is similarly shown by the heavy black line opposite June 17, which shows that 375 ft. of length (reaching therefore to Station 3 + 75) and 900 cu. yd. have been completed. The total actual cost is now $400, as compared with an estimated cost of $450, showing that the work is being handled satisfactorily.

If the chart is plotted on tracing cloth, blue prints are readily made. Instead of cross-hatching the performance area of each week, paints of different tints may be used.

On jobs of long duration, a similar chart showing progress by months is usually desirable, in addition to a weekly progress chart. Then it is often desirable to paint the area on the monthly progress chart, using the following colors of paints to designate the different months:

January	Chrome Yellow
February	Carmine
March	Payne's Gray
April	Deep Chrome
May	Prussian Blue
June	Burnt Sienna
July	Sepia
August	Emerald Green
September	Cobalt Blue
October	Vermilion
November	Indian Red
December	Sap Green

Charts of this sort should be prepared for each of the different classes of work, and, if the job is large, it should be divided into sections, each having its own progress chart. Finally, the manager should have a chart showing the progress of the job as a whole. To prepare such a chart, it is generally sufficient to reduce all the units of work done to the common unit of the dollar. To do this take the estimated costs, given in the fourth columns of all the weekly charts, and add them together. The sum will give the total amount of work done, based on the estimated unit prices. Then do the same with the actual cost columns. Plot these totals for the entire job, in columns side by side, as shown in Fig. 18.

This summary chart, Fig. 18, shows that the estimated cost of the entire job was $20,000 (indicated by $20M opposite 100%). It shows that the work was scheduled to begin June 1, and to be

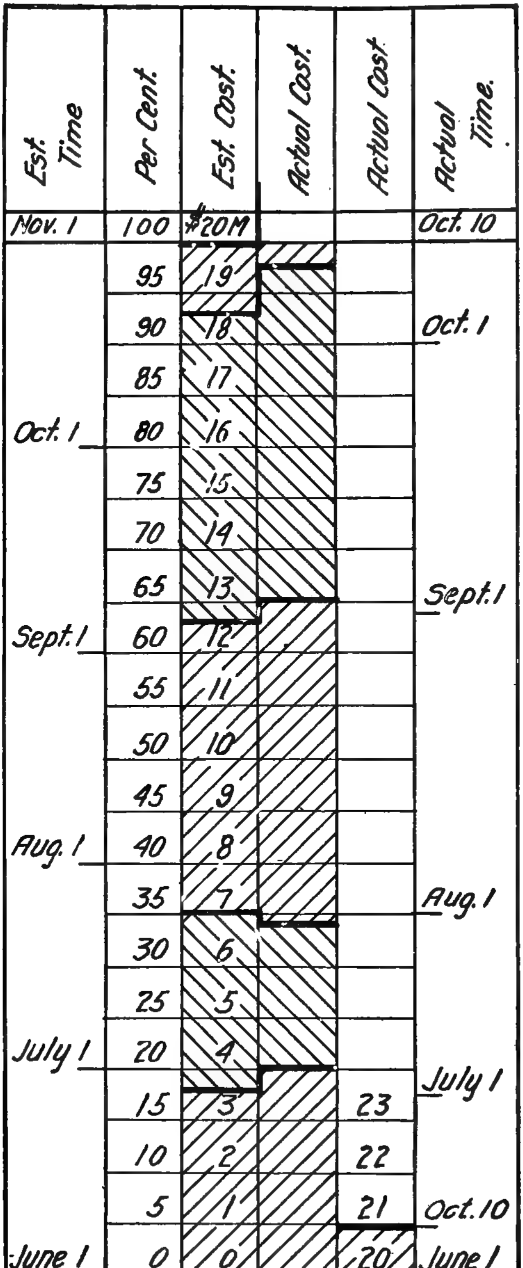


Fig. 18.—Progress and cost chart. Entire job.

finished Oct. 31. As a matter of fact it was finished Oct. 10 and its actual cost was $21,000.

On July 1, the total number of units of work done multiplied by their respective estimated unit costs amounted to $3,500, as shown in the second column; while the actual cost was $4,000.

On August 1. the total work done, at estimated unit prices, was $7,000, and its actual cost was $6,800. Only 35% of the work was finished, although the time schedule calls for 40%.

On September 1, however, the work is ahead of the scheduled time, and it also shows a greater cost than was estimated.

A similar condition exists on October 1.

The work is finished October 10, and since its actual cost overruns the estimated cost, it is necessary to plot the actual cost in the fourth column, where it is seen that it amounts to $21,000.

In preparing a time schedule, the first step is to take the time limit, as specified in the contract, and use this as the basis for planning the performance. A study of the plans and local conditions will determine what classes of work and what sections must be first started. Time schedules should be prepared for each of these, due allowance being made for the time required to deliver and install the plant, which is often an important consideration. If there is much plant to install, it is obvious that the intervals in the time schedule will not be evenly proportioned as in Fig. 18; but the schedule of performance for the first month or more will be much less than for succeeding months.

Once a time schedule has been carefully prepared, every effort should be made to live up to it, not only in toto but in every section, in order to prevent disorganization of the work. The function of the progress chart is to show how well the plans are succeeding.

History and Sketches of the Work.—As the work progresses, a brief—but not too brief—history should be kept of its progress, like the log of a ship. The organization of the forces, the number, kind and location of the machines should be recorded. Sketches should be made to show plant layout and local conditions. Sketches should also be made to show the types of construction. Large working drawings are usually too cumbersome to be of much value in any historical outline of the methods of construction.

Finally, when the work is completed, a complete history should be written in as condensed form as is consistent with a

clear understanding of its governing features. This should be typed and bound in a loose-leaf binder, together with the sketches and photographs that illustrate it.

Too much emphasis can not be laid upon the importance of such a written history, for memory, at best, is defective, and it often takes but a few years to render bare figures of cost almost worthless even to the man who gathered them. There is a further consideration—namely, that the employee who was most familiar with the work may resign or die, leaving the construction company with a mass of data that would possess great value if accompanied by a full sketch of conditions encountered and methods used, but which are more or less useless without such a sketch of conditions and methods.

Value of Progress Chart in Sinking and Concreting Deep Mine Shaft.—Richard L. Russell describes, in *Engineering News-Record* June 26, 1919, several novel details in underground construction developed and applied in the sinking and concreting of shaft No. 5 of the Miami Copper Co. at Miami, Ariz. This shaft has four compartments and is 936 ft. deep, and the concrete lining was carried on at the same time as, and without interference with, the sinking, 700 ft. of the shaft lining having been placed and two large stations having been excavated and concreted by the time the shaft had reached its final depth.

The following notes in regard to the progress chart, used on this work, are taken from Mr. Russell's article.

A chart was kept showing the progress made each day by each shift on each part of the work. A large-scale elevation of the whole shaft, stations, tunnels and ore pockets was made, and a certain portion was allotted to excavation, timbering, form work, reinforcing, concreting etc. To each shift boss was asigned a certain color, and the portion of the chart representing the location and the amount of work done was colored for the shift doing the work. The date was then written through the color. Quantities for this purpose were determined both by actual measurement and by the foremen's reports. For instance, the number of buckets of muck hoisted was a close check on the advance in sinking for that shift. The foremen were never formally notified that this chart was being kept, but within 2 days from the time it was instituted they all seemed familiar with it and watched it closely.

This chart not only furnished information as to progress at all

times and gave a comparison of the work accomplished by each shift, but it also served as a record which showed at a glance which shift boss had excavated any part of the work. If faulty workmanship had been discovered it would have been simple to trace it.

Probably the greatest value of the chart, however, lay in the competition it aroused among the shift bosses, who realized that their work was being closely followed and that they were getting due credit.

An Office System for Construction Work Covering Records of Plans, Progress and Cost and Bookkeeping Methods.—The following notes are taken from *Engineering and Contracting*, Dec. 17, 1913, by E. W. Robinson.

The following is a general outline of an office system that has been worked up and tried, with more or less modification, on five reinforced concrete jobs varying in size from $20,000 to $115,000. The cost keeping and progress charts were taken, with very few changes, from a system worked out by another, but the rest of the system described herein was worked out by trial from a knowledge of the results desired, aided by suggestions obtained from reading many articles in the various engineering and contracting magazines and treatises. A description of a system of this kind is useful in that it may suggest to another a way by which he can meet his difficulties along this line, but the variations in the classes of work encountered and the personal equation of what results are desirable preclude one from adopting without modifications the methods used successfully by another. Therefore this is offered in the hope that it will be an aid to some one who knows very well the results he desires to obtain but who through lack of practice in book and cost keeping, or for other reasons, is unable to secure them.

Records of Progress of the Work.—A more or less permanent record of the progress of the work is desirable for many reasons. It may save many dollars in future disputes or law suits, as well as be a great benefit in working out an analysis of the cost data. This is obtained by means of diaries, notes on the timekeeper's daily reports and photographs taken at regular intervals. The photographs perhaps offer the best evidence to be used in a law suit, especially where they are filed with a third party as fast as taken. At present a complete set is taken, showing all parts of

the job twice each month, with occasional sets taken in addition to show special features. The words "Progress Report," together with the name of the job, direction in which camera was pointed when exposure was made, and date are lettered on the file with Higgin's ink. By choosing a light place on the film or plate a very excellent title can be secured in this way. One of the reasons why photographs are so important is because they will show up many features that no one would think of entering in a diary for seeming unimportance, but which later may be of the

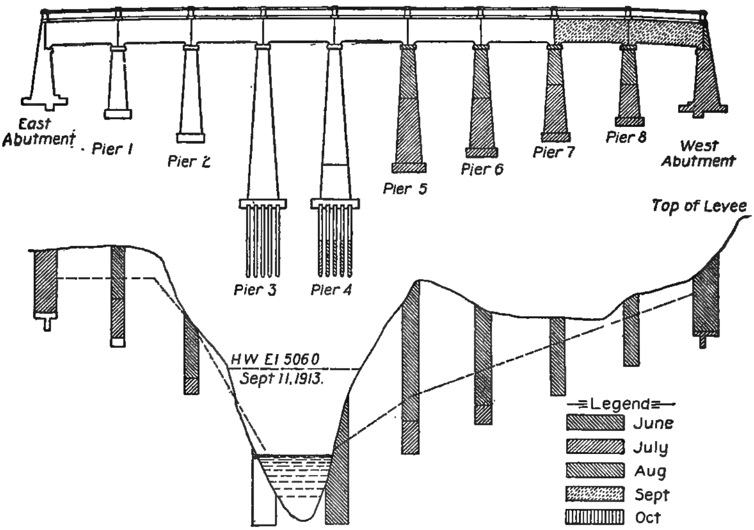


FIG. 19.—Specimen progress elevation and profile of a bridge.

greatest importance. The prints are trimmed to a uniform size and bound in a loose leaf binder in the order in which they were taken.

The weather report of the U. S. Department of Agriculture is received each day from the nearest weather bureau and filed as a permanent record of the weather to supplement the records of the daily reports. On bridge work a water guage is set near each job and a record made and plotted on cross-section paper of each and every change in the water level of the river. All unusual rises in the river are shown on the progress profile which is described later. This shows at a glance the effect of the high water upon the progress of the work.

An accurate record of the amount, kind, location, etc., of the various items of work done each month is obtained at the time the monthly estimate is made up and is shown graphically on a profile and on the cost charts. In the case of bridge work a profile on the longitudinal center line of the structure is plotted to some convenient scale, and directly above this is drawn to the same scale an elevation of the completed structure in outline only (Fig. 19). Different kinds of cross-hatching are used to show the location of work done during different months, and the same convention for a certain month is used throughout on all charts. This profile shows the method used in prosecuting the work, and is valuable in connection with the cost data, as it explains many things regarding unusual unit costs for any particular month. One must not expect it to be complete in every respect, for the reason that a drawing that would show every small detail would be so complicated as to lose its value as a picture which can be understood at a glance. On a concrete bridge this profile will show the progress of the excation, concreting, piling driven, together with any unusual stages of the river as stated in the preceeding paragraph.

The progress charts (Figs. 20 to 22) serve two purposes, to show the actual amounts of materials used and work completed and to give he costs of the same. The writer desires to state that methods here outlined for this feature were obtained from a series of articles by DeWitt V. Moore in "Municipal Engineering" about 2 years ago. The only changes made were those necessary for the differences in the class of work under consideration at the time. As shown in the accompanying figures they consist of parallel vertical columns which are filled with the particular kind of cross-hatching for the month in which the work was done. About two-thirds the way up from the bottom a heavy horizontal line is drawn through the columns to represent the estimated quantities and costs, or 100%. This line also represents the time for completion as shown in the contract. Then if there is estimated to be 1,000 cu. yd. of concrete to be poured, and the total time for completing the job is 4 months, if at the end of the second month there are only 250 cu. yd. in place, the cross-hatching in the quantity column under the heading of "concrete" will be advanced from where it was the previous month to a point 25% from the bottom line of the chart, while in the time column the same style of cross-hatching will be

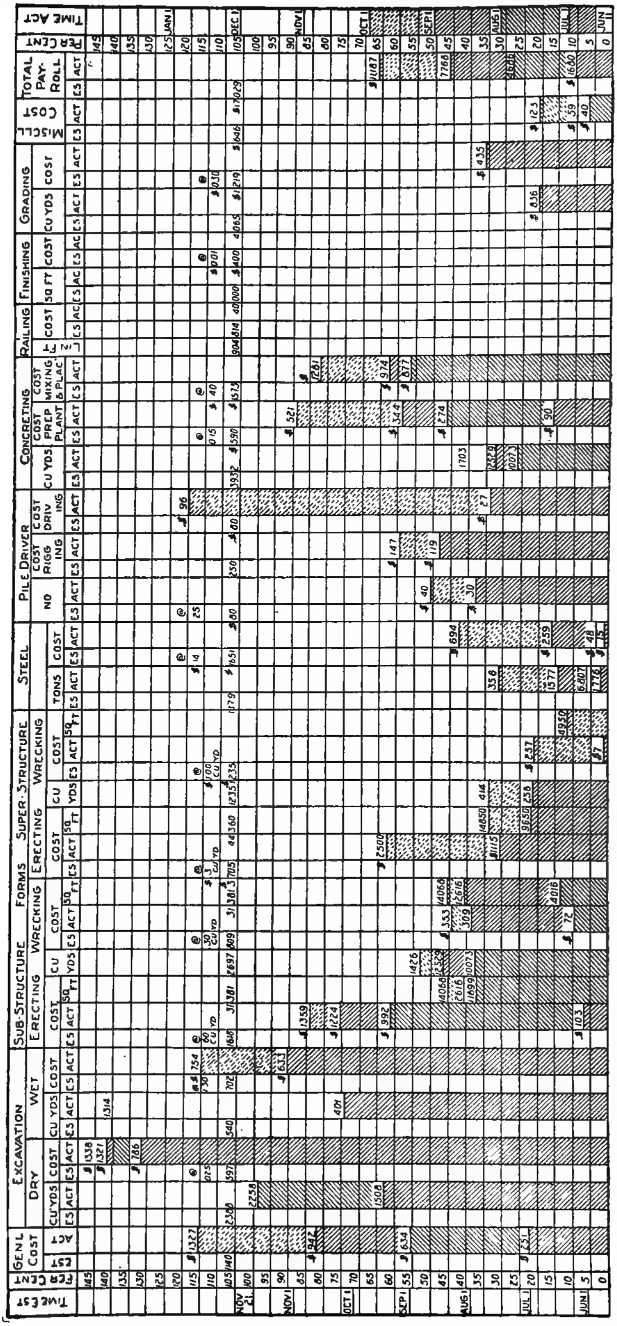


FIG. 20.—Chart showing expenditure for labor.

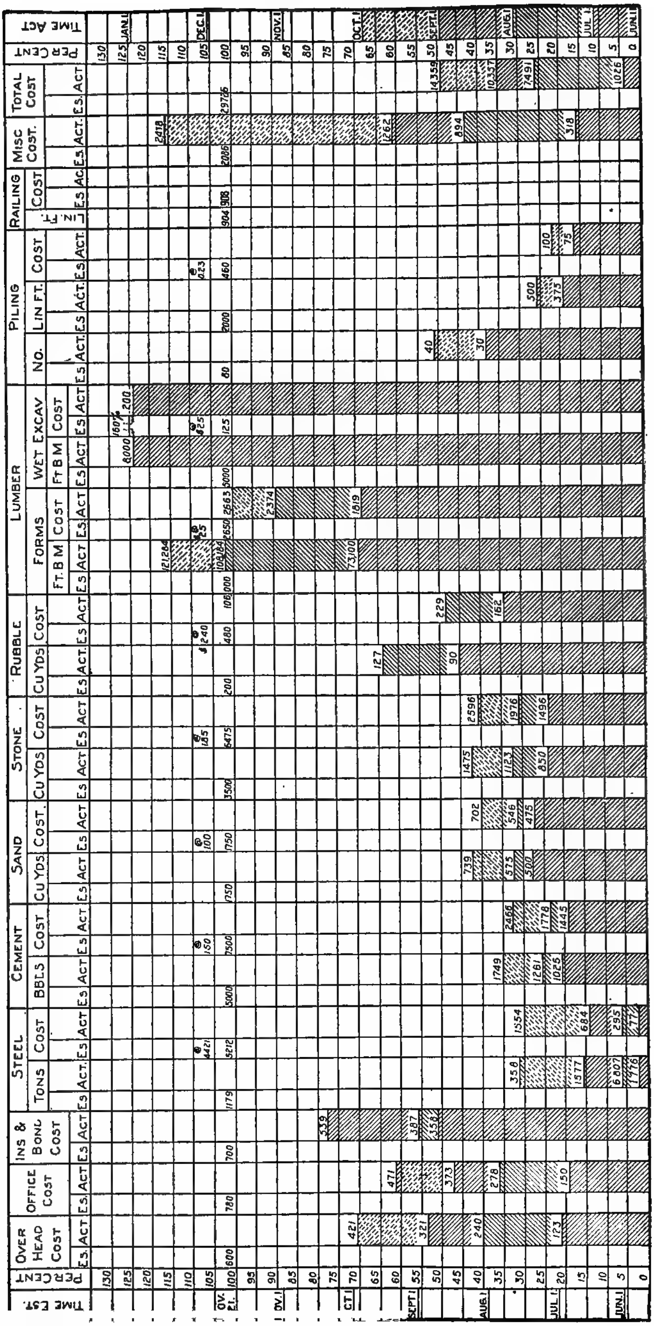


FIG. 21.—Chart showing expenditure for materials.

advanced to a point 50% from the bottom. This will show for that particular item we are only 25% completed, when to finish according to schedule time we should be 50% completed. On a large job with many items of nearly equal importance it requires

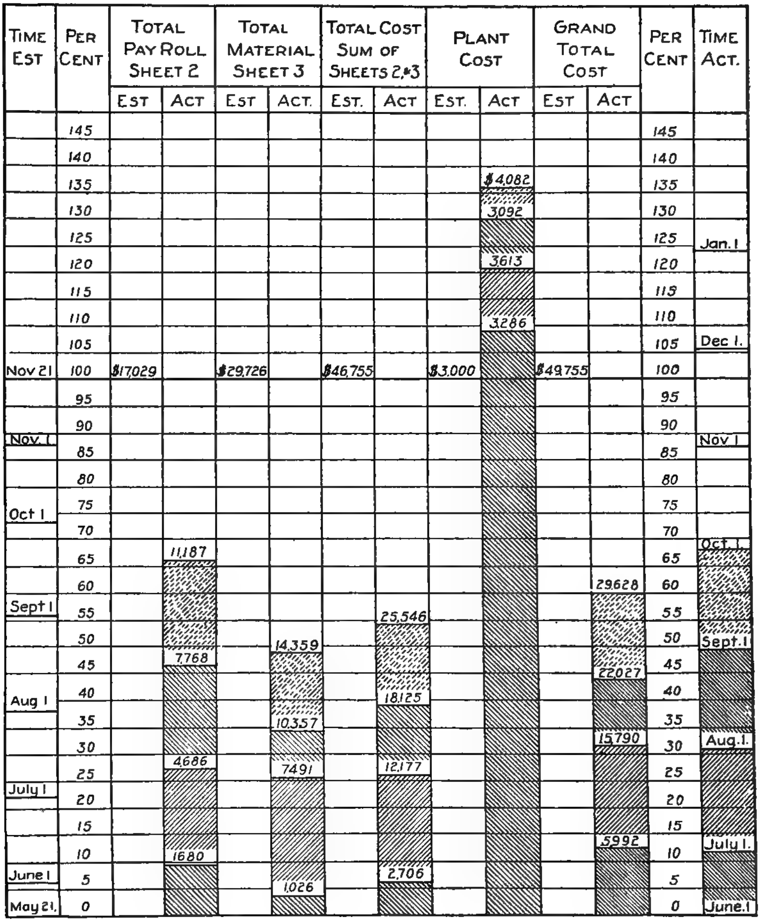


FIG. 22.—Chart giving summary of labor and material expenditure and plant cost.

judgment to state the stage of the work from these charts, for the reason that when our time is 50% gone several items may be 99% completed and others only 5% and the relative importance of the different items must be taken into account. The principal

value of the charts, however, is in showing the unit costs from month to month, and their variation according to quantities, locations, weather, etc. The same variation in regard to cost may exist as in regard to time. That is several items may run 200% or even more above the estimated cost for that item, and yet the job as whole be completed below the estimate. If the unit costs as a whole are running close to the estimated costs, then the total actual cost column, when compared with the time column, shows a fairly accurate representation of the rate of progress.

Three separate charts are made for each job. The first, Fig. 20, is called the Labor Chart and contains only the items shown on the pay-roll sheets. While there are some labor items that never get on the pay-roll sheets, the reason this separation is made is because of the ease with which a check is kept on the costs. The timekeeper makes out a daily report showing the distribution of labor to each item listed on the chart. This is made to check the actual pay roll each week. One of these daily reports is shown in Fig. 23. It will be seen at a glance how easy it is for the timekeeper to keep an accurate record down to the nearest half hour for each man on each class of work.

The unit costs for each month are written in small figures in the total cost column. These vary considerably from month to month, and would occasionally be cause for alarm were it not for the explanation given by the progress profile. For instance, one month the cost per square foot, or per cubic yard, too, for erecting forms for sub-structure was three times as high as it was the month previous. Turning to the progress profile we see that on this particular month the tops of four piers only were finished which had small yardage and superficial area, but were so cut up with offsets, curved surfaces, coping, etc., as to be very costly as compared with the massive work of the month before.

While the second chart (Fig. 21) is called the Material Chart it really shows all other items of expense not shown on the Labor Chart except that of plant or equipment. As shown, there are three items that are not material; namely, general overhead expense, office expense and cost of insurance and bond. All other items are material items and are taken directly from the books for that job. All hauling, loading and unloading, etc., of material is charged to material directly and not as a labor item. The unit costs of the different items on the Material Chart gives

the costs placed on the job ready to be incorporated into the completed structure.

The third chart (Fig. 22) is merely a summary of the first two, together with the plant expense, chargeable to that job. The first cost, in the case of new equipment, and the invoiced value in the case of second-hand equipment, is charged directly to each job as it is placed on the work. Then the sale price, if sold, or the invoiced value if moved to another job, is given as a credit, leaving the balance as the depreciation or cost of plant for that job.

Bookkeeping.—The system of bookkeeping was the hardest proposition run against, and was finally solved by the aid of an expert in that line who was not convinced that there was only "one" system. A construction business is so much different from most any other business that to get up a suitable set of books for a contractor one must look at the problem from a different point of view than he would in the case he were dealing with a merchant. For that reason most of the bookkepeers consulted could offer no suggestions worth while, but the one who did offer much valuable information had had some experience in construction work. Two books, loose leaf, are all that are needed to show in a convenient form every transaction. The first book might be called a book of "original entry" or "journal" so far as the purpose it serves is concerned. A copy of the page from this book is shown in Fig. 24. Every transaction that is to go into the ledger is entered into the ledger column. All items of cash receipt or expenditure are entered in the cash column. As all payments are made by check, this column, together with the check number column serve as a record of the checks issued and the balance at any time gives the cash standing at the bank or banks. The numbers in the check number column are checked off as the cancelled checks come back from the bank and here any errors between the original check and the stub from which the entry was made are picked up. After the cash columns are a number of blank columns which are to be lettered with the proper heads according to the charges to be made. Each full sheet has rulings for 26-charge items and where two or more jobs are being carried in the same book, or where for other reasons more detailed distribution is desired, short sheets are inserted. These short sheets are just the right length to let the main columns show when it is turned to the left. This book measures 16 by 36 in. when

DAILY REPORT

McKINZIE-WILLIAMS CONSTRUCTION CO.

Job–Date *Distribution*

No.	Name	Occupation	Total hrs.	Rate per hr.	Total amt.	Check Column Hours																	Forms					Pile Driver			Concreting					
																							Sub-Str.		Super-Str.											
						6. A.M.	7	8	9	10	11	12	1	2	3	4	5	6	7 P.M.	X General	A Dry Exc.	B Wet Exc.	C Erecting	D Wrecking	E Erecting	F Wrecking	G Steel	H Rigging	I Foundation	J Temporary	K Mixing and placing	L Preparing plant	M Railing	N Finishing	O Grading	P Miscel.

Totals

Foreman

Total Hours
Total Nearest Dollar
Sacks Cement

FIG. 23.—Form used for daily report.

McKINZIE-WILLIAMS CONSTRUCTION CO.

Webb City, Mo.

Page No. Month of

Date	Name	In payment of inv.		Ledger		Cash											
			Date	Debit	Credit	Debit	Credit	Ck. No.									

Total Debits
Total Credits
Total Charges

FIG. 24.—A page from book of original entry.

open, or 16 by 18 in. closed. Every fifth horizontal line is of a different color from the main ruling to serve as a guide line.

The second book is an ordinary loose-leaf, stock ruling ledger such as is in general use for all purposes. All accounts that are not paid immediately upon the receipt of the goods are entered in the ledger from the ledger columns of the book of original entry.

On all car load lots of material the invoice is entered and distributed to the proper charge column as soon as received. On other accounts, where there are a large number of small items, the entry is made and distributed when the statement for the whole month is received. For this reason the books are not closed until the tenth of each month. Individual accounts are carried in the ledger for all firms where the company is a regular customer. All other accounts that are not paid by the tenth of the month are entered as miscellaneous accounts payable. Delivery tickets are brought in from the job each month and checked against the invoices and statements. All invoices and statements are checked in regard to quantities, prices and extensions, and many dollars are saved in a year in this way that would be otherwise lost. It is a surprising fact that the monthly statement of some firms are invariably correct, while of others they are nearly always wrong in some particular. A memorandum is made of all special prices given orally by salesmen when orders are placed.

Pay Roll and Pay System.—The timekeeper on each job keeps the time of the workmen in a weekly time book. All timekeepers, foremen and superintendents meet in the office on Friday of each week to discuss plans, etc., for the coming week and to work up the time for the week past. These time books then are turned in to the office man who checks them over thoroughly before making out the pay roll next day. All the men on the pay roll are paid in cash, and this makes it necessary to make up a list of the amounts of the different denominations of currency needed so that each envelope will contain as few pieces as possible. This causes considerable work, but not as much as that of writing checks, neither is it as costly as the latter. While there may be some disadvantages in paying off in cash, there are also several advantages. A piece of "real" money feels good to the average laborer, especially a negro, and other things being equal they will prefer to work for the man who pays in cash than one

who pays in checks. Then, too, this method prevents the possibility of having a check "raised."

The office man copies the pay roll from each book on to a pay-roll sheet each week which gives a duplicate record for the office files to serve in case the field book is lost or destroyed. On these pay-roll sheets are listed the totals from which the liability insurance is based, making it an easy matter for the insurance company's auditor to go over and check the totals.

Material Records.—A level or transit book is fitted up with the proper headings and placed on each job in which the material man keeps a record of all car load lots of material received and unloaded. Such information as car number and initial, dates set and unloaded, and by whom it was unloaded, together with any miscellaneous notes that are desirable is kept in this book. A daily record of the amount of cement used, with the member in which it was placed, is also kept in the material book. This book is brought to the office every Friday night and the items listed during the week are copied by the office man into a duplicate book kept in the office all the time. The headings in the office material book are the same as those in the first book, with additional ones to show weights, etc., and other information obtained from the expense bills and invoices only. The cost of keeping this record will more than pay for itself in the saving effected in demurrage bills, for most railroads are rather careless in their records of car demurrage when no one is keeping a close check on them. By system of checks between the invoices and material books the amounts, dates received, etc., can be told at once for any particular material on each job. This record has several times saved the company from paying for a car of stone or sand that was billed and invoiced to them, but unloaded by mistake by other parties, and which might be easily missed when a large number of cars were being received and unloaded daily on the same switch. Where sand or stone is received on the job, in wagons from local pits and paid for by the cubic yard, the material man gives each teamster a printed ticket with his name, the date received, and the dimensions of his load, written in the spaces provided, leaving a carbon copy of each ticket in the book for office use. Where the material man understands the use of the slide rule he figures by the cubic yards from the dimensions while the wagon is unloading and puts that on the ticket

also. Otherwise this is done by the office man after the carbon copies are turned in to him each Friday night, and the man furnishing the material is paid from these carbon copies of the tickets issued. The dimensions are marked on the sides of the wagons with red kiel and show the length, width and depth of the box when level full. They are checked occasionally to see that false bottoms are not slipped in to lighten the loads, and when the load varies from level full the receiver estimates the number of tenths of a foot above or below the full line.

Plans, Drawings, etc.—Before any forms are erected on the job the general scheme is worked out in the office. In most cases blue prints showing sketch, sizes and spacing of important members, together with the principal loads coming upon them, are made and sent to the superintendent on the job to be followed in the erection. However, in many cases the design is sketched to scale on this typewriter paper in pencil, and one of the two carbon copies sent to the field. On these plans or sketches only the general layout or scheme is shown, together with the limit of sizes of the different members, the details being purposely left to the discretion of the superintendent, or carpenter foreman in case of form work. The reason for this is obvious, a good carpenter being generally able to work out a more economical detail than the man in the office. It is well to consult freely with the practical man on the job, for a great deal can often be saved in this way.

All plans and sketches are filed in the office in such a manner as to be readily accessible. All sketches made on typewriter paper are punched and filed in a loose-leaf note book cover. All blue prints and large drawings are filed with the engineer's plans of the structure in a rack built for the purpose and which is so arranged as to hold each sheet flat open and easy to get at without disturbing the rest. This method applies only to the drawings and prints for one particular job, for as soon as a job is finished all data for that job is filed in drawers together, as it is only seldom they are needed for reference.

A Method of Determining Time of Performance of Work with Special Application to Grading.—The time factor in construction work is a variable which is dependent upon many conditions and is often of considerable importance. It appears that a practical method of approximating the number of work-

ing days to be allowed for a given contract is by carefully segregating, analyzing and averaging portions of similar work performed under approximately the same conditions.

In a paper before the Society of Municipal Engineers of the City of New York, G. L. Bennett, efficiency engineer for the New York Board of Estimate and Apportionment, presented a general discussion of this subject with a detailed method of handling grading work, which is in use by R. H. Gillespie, chief engineer of sewers and highways for the Borough of Bronx, New York. While the methods and costs given apply directly to New York City conditions, the method of approaching the problem is applicable to any locality.

Contracts commonly arise from demands which in themselves are either urgent and set for a particular time of fulfillment or are more complaisant as to time, requiring only ultimate completion within rather wide time limits.

Contracts of the former type, for emergency, work or for supplying necessary links in larger schemes, can in porportion to their needs, afford to sacrifice economy for dispatch. Contracts of the latter type, which includes a majority of street improvement work, can properly afford to disregard time as such and to seek economy of total costs alone.

Definition of Contractor's Economical Time.—There are comparatively few pieces of work which can only be economically accomplished by the use of some one particular equipment and of some one particular method. In general, there are a number of equipments and methods which, depending upon the genius of those in control for management under the conditions obtained will yield economical results, but will require somewhat different times for completion. Leaving out of account variations in required time due to such causes there is for each sort of work some number of working days, more than which could not economically be used by the contractor. Thus, on a pick and shovel job, the employment of less than a certain number of men would not be economical because of the cost of the foreman and superintendence; similarly, the use of more than a certain number of working days by a contractor would be uneconomical. The same thing applies to any job for which an equipment and force are provided sufficient to complete that job in one of the perhaps several most economical ways so far as contractor's costs

are concerned; and to this somewhat varying time may be applied the term, "Contractor's Economical Time."

Equipment Warranted.—It is to be recognized that small total contract quantities, in general, only warrant the employment of light and easily moved equipments and that as the quantities become larger more and still more effective equipments are warranted.

But this may be modified considerably by the amount of work of this nature done or yet to be done, in the locality of the contract in question. Thus a rather small contract for rock excavation could properly be given a shorter contract time in the northern part of Greater New York where rock excavation is constantly in progress than it could somewhere out on the shores of Long Island or southern New Jersey.

Relation of Labor Cost to Equipment.—The amount of equipment to be employed is seriously effected by the costs of labor and the ease of procuring equipment. Where satisfactory labor is expensive or difficult to procure, contractors will, in general, employ machinery of a type which otherwise would only be used on much larger contracts, resulting, of course, in a shorter contractor's economical time. Where machinery can be easily hired, equipment will often be used on small jobs such as could not otherwise be afforded. This affects also very large jobs for which, where no satisfactory disposal can be made of worn machinery, equipment is often provided only in such quantities that it shall all be practically worn out when the job is completed.

Definition of Total Cost.—The total cost of the work rather than the cost to the contractor is the matter which interests the engineer in his capacity of manager for the party contracting for the work. And the total cost is, of course, the contract price plus the costs of surveys and designs, plus the costs of inspection, superintendence and interest on the moneys invested by partial payments or otherwise, all of which latter vary nearly directly with the time taken for the work.

Two Methods of Determining Time.—Two methods of ascertaining the time to be allowed were open:

Method A.—By the balancing of inspection, superintendence, interest and similar time charges against the increased costs of obtaining and operating equipments of more capacity than are required to complete the contract in the contractor's economical

time. That point on the curve which gives the least total cost, is the correct time to allow for the contract.

Method B.—By plotting the times allowed on previously completed contracts composed mainly of one kind of work and which had, in the judgment of the engineers in charge thereof, been prosecuted vigorously and with adequate equipment, a series of curves of quantity with reference to time can be drawn for each kind of work, each curve recognizing in its equation some particular controlling factor of variation. Having such curves and knowing the total quantity of work to be done, the proper contract time can be ascertained and the results combined to give the time for a contract including various kinds of work.

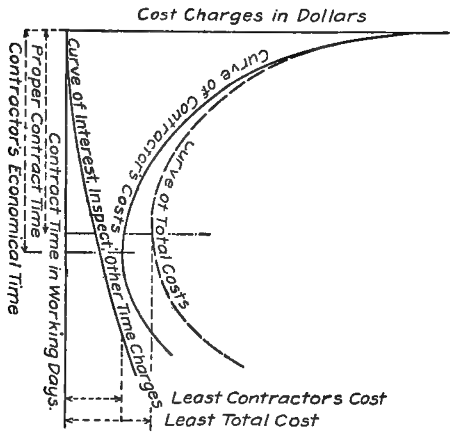


FIG. 25.—Curves showing the relation of total cost to contractor's economical cost.

Method A.—The operation of the first method for arriving at the contract time is shown diagrammatically in Fig. 25.

In Fig. 25 the curve of contractor's costs shows the variation in cost with the contract time; the curve of interest, inspection and other time charges, the variation of these with contract time. The curve of total cost which has for its ordinate at each point the sum of the ordinates of the other two curves at that point, shows the variation of both with the contract time.

The cost of interest, inspection, etc., will decrease therefore with a decrease in contract time, but because of the greater cost of equipment, etc., necessary to complete the work in less than a contractor's economical time, the contract price will tend to

increase. That time which will give the minimum total costs for the work which should accordingly on this sort of contract be used as the "contract time," will therefore be somewhat shorter than the "contractor's economical time."

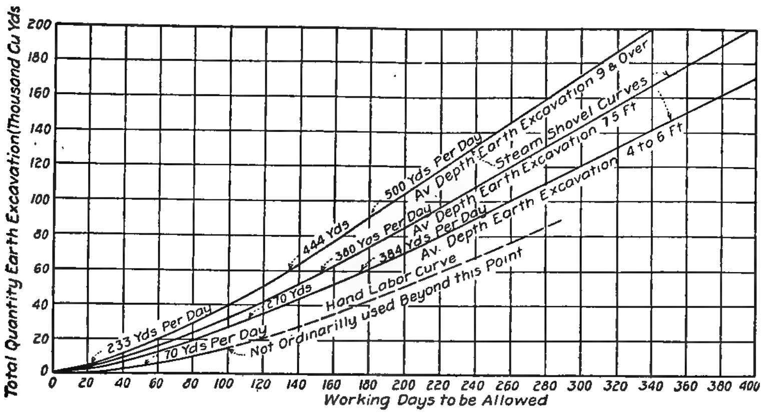


FIG. 26.—Curve for earth excavation.

As these curves do not show variations with regard to quantity or other conditions governing any one sort of work, one such set of curves is necessary to determine the proper contract time for each total quantity of each kind of work. The contract times

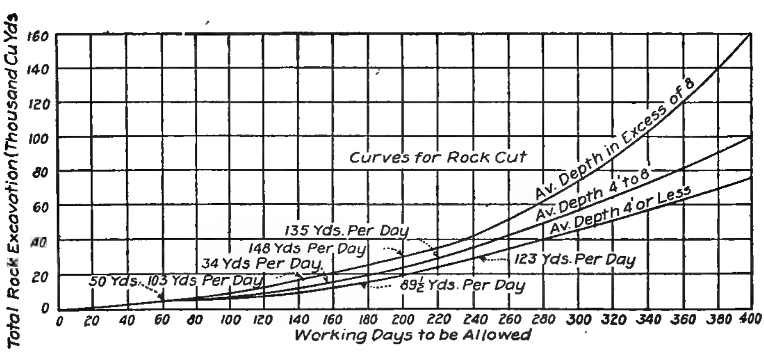


FIG. 27.—Curve for rock excavation.

can later be plotted against the total quantities as has been done for Method *B*, shown in Figs. 26, 27 and 28.

It is to be noted that this method depends upon a curve of contractor's costs, which can be determined, point by point, for

the total quantity and the kind of work to which this curve applies, only by designing the most efficient plant or equipment to do this amount of this kind of work in each of the varying times assumed and from the use and costs of these plants or equipments, arriving at the contractor's costs.

There is a very considerable difference in judgment as to the most economical plant for any given contract time and total quantity of work to be done and still more difference as to the delays and other items summed up in the contractor's costs. This is apparent to those who are familiar with the variations in bid prices on works of such magnitude as call for new and specially designed equipments.

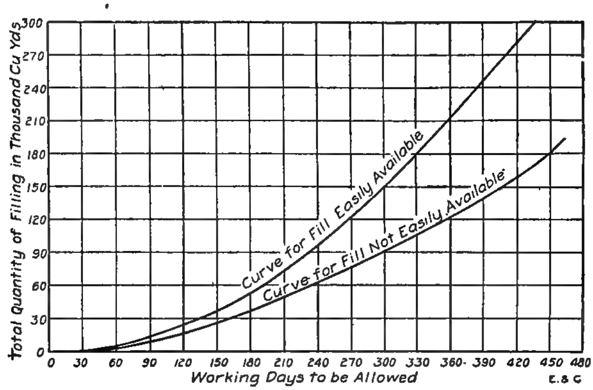


Fig. 28.—Curve for filling.

And that the very considerable variation in bid prices between the various bids received for any contract is not all due to differences in the profits which the different bidders desire, is quite clear to those who have studied prices bid when work was scarce and when, therefore, most if not all the bidders were competing keenly for the job.

That there is ample room for considerable differences between even the most carefully estimated contractor's costs and the actual costs is quite evident to those who have planned and estimated and later built and operated contractor's plants.

Method B.—In view of the large number of assumptions which must be made and the work involved the first method has been discarded in favor of the second.

RULES FOR INTERPRETING CURVES USED IN METHOD B

Determination of Contract Time.—To determine the number of days which shall be written into any contract for regulating and grading as the number of working days to be allowed, the curves hereto attached are to be used in accordance with the rules herein given.

Explanation.—The work to be done will consist of items of rock or earth excavation or of filling or of both, of curb, of flagging, and of bridge-stones. These may or may not be accompanied by walls of dry rubble, rubble in mortar or concrete; by pipe drains; by inlets; by receiving basins; by manholes; by piles; and by special constructions.

Items Which Govern.—Ordinarily, work on more than one of these items can be prosecuted at the same time. Care is therefore required to so use the information available of the special conditions surrounding a proposed work as to eliminate from consideration all of those items and all parts of items which can properly be done during the progress of some other item. There will thus be left as the determining factor in the required time for such work one or, more rarely, two main items which can not be done simultaneously and some preliminary and subsequent parts of items.

The main items are liable to be earth and rock excavation or filling. The preliminary parts of items: the excavation of sufficient earth to permit earth and rock excavation to progress simultaneously; the building of sufficient of the pipe drains, inlets, manholes or basins to permit such buildings and the filling to progress simultaneously or the building of sufficient walls, in those few cases where such wall is necessary before any filling can be done, to permit such wall building and filling to progress simultaneously. The subsequent parts of items: special structures which can not be completed until after the main item is completed curb, flagging or bridgestone.

The curves have been drawn to recognize, in view of the total quantity of an item to be done, the equipment and force which should be used.

They show, accordingly each for its condition, the amount of time for any total quantity which should be consumed in completing that quantity.

Rule 1.—If the time for a part of an item has to be estimated, it is to be taken therefore at the same rate of accomplishment per day as is the total quantity.

Rule 2.—Where conditions are clearly intermediate between those shown by the curves, interpolation is permissible, but where doubt exists it is preferable as making for lower costs to take that nearest diagrammed condition which gives the longer contract time.

Rule 3.—Where a part of an item comes clearly under one condition recognized in the curves and the remainder as clearly under another, unless the equipment and force which should properly be used for doing these two parts is widely different, the time for the two parts, each taken at the same rate of accomplishment as if the total quantity came under that part's condition, shall be summed to give the time for that item.

Rule 4.—If the equipment, etc., should properly be different, the time for each part of the item is to be taken as if the quantity for this part item were a total quantity and the times so obtained, summed to give the total time for the item.

Note.—It is to be remembered that the contract provides that allowances of time for delays occasioned by the weather, or by any act or omission on the city's part, are to be made in addition to the number of working days. No consideration need be given in their determination to any conditions arising from such causes.

The curves represent average good practice as determined from the records of many contracts. They do not represent the greatest progress which can be made under good management, and if, therefore, conditions arise not provided for in these curves, such as inability to attack the work in more than a few points, unless the condition is very severe, no additional working days are to be allowed as a total.

Rule 5.—For time necessary to get the work started after being ordered ahead and for stopping, after completion, 10 working days are to be allowed as a total.

Typical Examples.—The following examples are given to illustrate the use of the curves.

Example 1.—On a contract with a center line length of 8,900 ft. and a street width of 100 ft. there are the following items and quantities.

Earth excavation	88,000 cu. yd.
Rock excavation	26,700 cu. yd.
Fill	151,100 cu. yd.
Dry rubble masonry	700 cu. yd.
Rubble in mortar	25 cu. yd.
12-in. pipe	100 lin. ft.
18-in. pipe	575 lin. ft.
Manholes	4
Guard rail	5,800 lin. ft.
Lumber	7,500 ft. (B. M.)

Filling.—It is known that over a portion of the work where filling is required the street is located on a swamp where settlement will, in all probability take place. Assume that this settlement will amount to 30,000 cu. yd. Then the total filling required to complete the work would be 151,100 + 30,000 = 181,100 cu. yd.

The sum of the earth and rock excavation amounts to 114,700 cu. yd. It should be assumed that the entire excavation is to be applied to making the fill so the material can be considered as easily available.

The balance of the material required for filling (66,400 cu.yd) must be obtained from outside sources. It is further known that the swamp section of the street is near tide water where material can be obtained by scows. This material, so obtained, should be classed as material "easily available." Even though the dock or nearest obtainable landing may be at some distance from the street under consideration, and especially in view of the possibility of obtaining and placing this filling during the progress of the grading on other portions of the work, it should be classed as "easily available."

An examination of the filling diagram will therefore indicate that considering 181,000 cu. yd. as "easily available," 332 days should be allowed, and adding to this 10 days for starting and stopping, we have 342 days, or say 345 days for the contract time.

Excavation.—If, on the other hand, we consider the excavation and know that the earth cutting averages from 4 to 6 ft. in depth, and the rock 4 to 8 ft. in depth, and that 10,000 cu. yd. of earth must be excavated before rock excavation can begin, and that thereafter both will be carried on simultaneously, we will obtain from the curves the following:

10,000 cu. yd. earth excavation (at 88,000 rate)	27 days
26,700 cu. yd. rock excavation	212 days
	239 days
Starting and stopping	10 days
	249 days

If we consider only the earth excavation, and assume that while same is in progress the rock will be excavated, we have from curves the following:

88,000 cu. yd. earth excavation	235 days
Starting and stopping	10 days
Total time required	245 days

It is evident from the above that the filling required on the work controls and that the contract time should be fixed at 345 days.

Example 2—

Earth excavation	1,000 cu. yd.
Rock excavation	500 cu. yd.
Filling	120,000 cu. yd.

In this example the excavation is plainly not to be considered. The filling if easily available will by the curves require 268 days. If not easily available, filling will require 357 days.

To either of these 10 days should be added for starting and stopping, making either 278 days which call 280 days, or 367 days which call 370 days.

Example 3—

Earth excavation	6,000 cu. yd.
Rock excavation	6,000 cu. yd.
Filling	12,000 cu. yd.

If earth overlays rock, the quantity of earth which must be removed to permit rock and earth excavation to progress simultaneously, must be determined from a knowledge of the local conditions. If these conditions show that say, 35% of the earth has to be removed before the rock excavation can be properly commenced, and that the rock has an average depth of 4 ft. or less, the times required for excavation will be:

For earth 35% of the 64 days required by curve for hand labor for 6,000 yd.

For rock 114 days required by curve for 6,000 yd. of average depth 4 ft. or less.

The sum of these two, plus 10 days for starting and stopping equals 146 days which call 150 days.

The filling, which is all easily available, would only require 90 days.

Therefore the contract time for this job would be 150 days.

If earth and rock are in separate cuts and separately approachable so that the two sorts of excavation can properly progress simultaneously, the earth excavation need not be considered. The filling will, of course, not be the determining factor and the rock excavation will be. Under these conditions, the contract time should be for rock excavation, 114 days plus 10 days for starting and stopping equals 124 days, say 125 days.

Example 4—

Earth excavation	20,000 cu. yd.
Rock excavation	2,000 cu. yd.
Filling	3,000 cu. yd.

In this case, the earth overlies subgrade rock throughout most of the work.

The rock excavation remaining to be finished after the earth excavation is completed will amount to about 18% of the total rock excavation.

The filling will not determine the required time.

The earth excavation being all in shallow cut will be taken out by hand labor, thus requiring 118 days.

The 2,000 yd. of rock, 4 ft. cut or less, would require 36 days, and 18% of this would require 6 days.

The sum of the above plus 10 days start and stop equals 134 days which call 135 days.

Example 5—

Earth excavation	1,000 cu. yd.
Rock excavation	6,000 cu. yd.
Filling	7,500 cu. yd.

Here, the 1,000 cu. yd. earth overlies the 6,000 cu. yd. rock and the conditions show that only a very little earth will be

taken off, say, 200 yd. before the rock is commenced. Two hundred yards earth should require about one-fifth of the 24 days required by hand labor curve for the total 1,000 yd., say 5 days.

Six thousand cubic yards rock, of a 4-ft. or less depth of cut, requires by the curve 114 days.

The sum of the above plus 10 days for start and stopping, equals 129 days which call 130 days, contract time.

Example 6—

Earth excavation	30,000 cu. yd.
Rock excavation	45,000 cu. yd.
Filling (easily available)	120,000 cu. yd.

The filling will require by the curve 268 days.

The earth and rock excavation are such that they can be prosecuted quite simultaneously. The rock excavation will therefor control and has an average depth of 6 ft., requiring by the curve 270 days, so that 270 days is good for either.

Therefore 270 plus 10 days stop and start gives 280 days as the contract time.

The application of this method to others of the more usual types of municipal work is obvious and in some cases is under way.

The confidence of contractors in general in the absolute fairness and in the knowledge of the engineer, will, perhaps as much as any other factor, tend to lower the costs of work to be done. And to this end a uniform method of figuring the contract time rather than guessing at it, will, it is believed, contribute in no small degree.

It is probable that the curves herein given will require modification in some instances to make them fit to the experience of other localities, and it is possible that a further study of data similar to that upon which these curves are based may lead to somewhat higher or lower averages of performance, resulting in shorter or longer contract time.

Economical Speed in Building Construction.—The conclusion of one of Aberthaw's Texts[1] reads as follows: "The judgment and experience of the estimator, in any given instance, must be relied upon to evaluate the influence of modifying elements of time, place and special circumstances." Angus B. MacMillan, Engineer of the Aberthaw Construction Co., in an article in

[1] Estimating Concrete Buildings, by Clayton W. Mayers, 1920.

the May, 1920, Industrial Management, has elaborated on the time element and has put a rather abstruse subject into concrete terms. Abstracts from his able article, as given in Engineering and Contracting, May 26, 1920, follow:

Except where such speed is required as to necessitate purchasing materials from stock, at a price necessarily higher than where they may be obtained from the mill, the three main variables entering into the cost of building are the cost of the forms, the plant and the overhead expense. If the time of construction is to be shortened, the first two variables will be decreased, but the third will inevitably be increased. Due to the fact that the forms account for a much larger proportion of the total cost than do the other items, any material increases in the cost of forms will more than offset any possible gain from the other two items. When, however, account is taken of the interest on the money tied up in construction, without even considering the value accruing to the owner from his ability to occupy the building sooner, a nice balance may be struck. It is in selecting the point at which the gains from decreased cost of some of the items, an increased availability will overbalance the extra cost for forms, that judgment is shown to best advantage by the contractor.

Effect of Slow Construction on Overhead and Cost of Forms.—For a typical building, figures have been prepared on the basis of which a diagram is presented (Fig. 29). These figures show the way in which the increasing cost of forms progresses as the building period is successively shortened, and the way in which at the same time the overhead costs decrease with the speed. Superimposed upon these curves is one which represents the accumulating interest on the money invested, which becomes heavy under the slow construction period. This compound cost, as shown by the resultant curve, shows that the minimum is reached at a point somewhere between the most rapid and the most leisurely construction. In other words, urgency for a building must be very great if the highest speed is to pay; while on the other hand, a very slow speed of construction is also more expensive than moderately rapid progress.

Factors That Influence Cost.—When too large a number of men are placed on a job, not only do they get in each other's way and thus interfere with each other's individual efficiency, but also the problem of bossing a job is greatly complicated,

because it is usually necessary to employ one gang boss or leader for each 10 or 12 men, and in some cases for even smaller gangs. The added cost due to this loss of efficiency is, of course, offset against the gain in time in delivery of the building. The added bosses form a definite addition to the overhead on the job, particularly where the overcrowding of men is considerable.

In the construction of a building, story by story, the time limit makes itself apparent primarily in the number of stories. There is no limit in the horizontal direction, except that im-

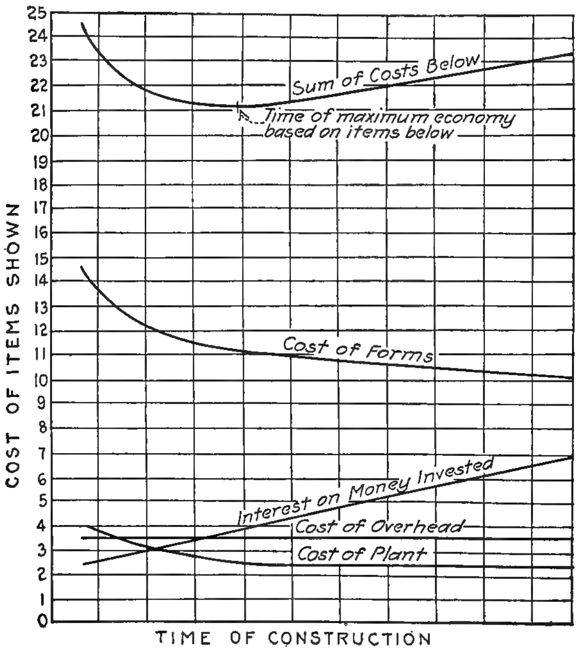


FIG. 29.—Economical time of construction.

posed by the consideration of the number of men who can be effectively employed, and the necessity for an unfailing stream of materials as they are needed. But when it comes to adding stories to the building, the necessity of waiting after each story is poured until it is thoroughly set, before the next story can be touched, makes a very distinct limit and requires a careful schedule if satisfactory progress is to be made.

Speed Limited by Supply of Materials.—The limitation upon speed and efficiency based upon the ability to get materials

as fast as they are wanted, and yet not fast enough to clog the works, is important; and there is another limitation based upon the character and capacity of the equipment used on the job. In two large textile mills now being erected by our company in Nashua, N. H., and Lowell, Mass., respectively, it happens that in each case the full capacity of the gravel banks in the neighborhood is being utilized. As gravel forms the largest bulk of materials entering the job, and as the principal cost of gravel lies in the cost of delivery from the bank to the job, it is evident that only an emergency requiring extraordinary speed in construction would make it feasible to go farther afield for other sources of supply, with the attendant increase in cost of delivery.

In one of these cases it happens that the layout of buildings in the neighborhood of this particular job is such that it was possible to locate mixers in one place only, and in this place two mixers have been put. Good practice requires that the mix be in the mixer one full minute. As it takes about 15 sec. to fill the mixer and about 30 sec. to empty it, this makes a net time of 1¾ min. per batch. In practice, however, unavoidable minor delays easily increase this time to two minutes, so that the best work which can be expected from each mixer is 30 batches per hour.

At 18 cu. ft. per batch this becomes 20 cu. yd. per hour per mixer, or 320 yd. per 8-hr. day for the two machines. That these machines are actually being operated at practically their full limit of capacity is indicated by the fact that about 2,000 yd. of concrete are being poured per week on the job, with 1 hr. of overtime per day, a part of which extra hour is always used in tuning up at starting and cleaning out at stopping.

Sequence of Crews.—On a small concrete job, where the carpenter crew is only one day ahead of the mixer crew and the steel men working their heads off in between, and then frequently having to work half the night to get ready for the next day's run, everybody is in everbody else's way and confusion is the result. An ideal schedule puts the carpenter crew two days ahead of the mixer crew and the steel crew half way between. On a large job this schedule is very easy to maintain, and gives excellent results. It enables the steel men to do their work within the allotted daily hours, avoids confusion and saves much interference and hard feeling.

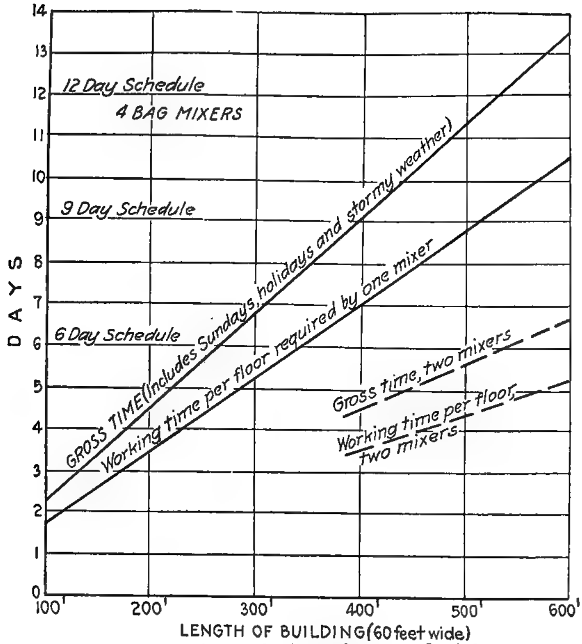


FIG. 30.—Apportioning mixers to the job.

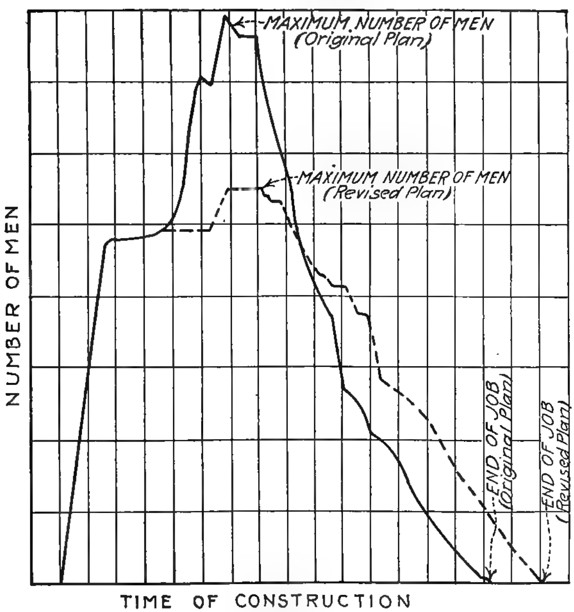


FIG. 31.—Broadening the labor peak.

In a building measuring 200 by 60 ft., which is a very common size for light manufacturing, we have 12,000 sq. ft. per floor. Including walls, columns and beams, this represents the pouring of about 15,000 cu. ft. or 555 yd. of concrete per floor. With a mixer furnishing 160 yd. per day, a floor may be poured completed in 3½ working days. If the schedule of forms provides for two floors at once, with a corresponding period approximating 9 days between floors, this means about 7 working days after deducting Sundays and the inevitable spells of weather when work simply cannot be prosecuted effectively. As the one mixer can handle the job in 3½ days, it follows that it is operating only half the working time. See Fig. 30. The mixer crew consequently has to be given other work over the balance of the time unless a smaller mixer is used, in which case the mixer crew is larger per unit of output than with a mixer of standard size, and consequently the unit cost is higher.

Number of Sets and Reuse of Forms.—If the job permits the use of three sets of forms, and consequently reduces the average time per floor to six days, the mixer is kept busy nearly the entire time, and a much better mixer efficiency is obtained without using the men for other work. If, on the other hand, it is planned to use only enough forms for one floor, and to strip and reuse these forms, the schedule is opened up to 12 days per story, of which 9 or 9½ days are working days. Here the mixer; capable of doing its work in three and a half days, is working considerably less than in 40% of the time.

A modification of the above reasoning may be found on large buildings, even though the period between floors be as great as 12 days. For instance, on a five-story building, where the length of building was 500 ft. and the schedule was 12 days, with about 25% more forms than were necessary for one floor only, the mixers were so adjusted to the job that they were kept continuously busy in furnishing concrete for bay after bay, until the end of the building was reached. By this time the 12 days' period at the other end had elapsed, and the second and subsequent floors could be poured immediately after the completion of the far end of each next lower floor.

Under conditions such as those obtaining in connection with the building of a plant for emergency war work, like this, or as in the case of the destroyer plant at Squantum, consideration of cost of forms does not enter. Here the requirement was to get

the buildings out in the shortest possible time in which they could safely be constructed. Sufficient lumber to take care of all necessary simultaneous form work was on the job, and there was no hold-up in waiting beyond a reasonable time for the concrete to set.

Distribution of Man Days.—In one case in New York state, however, a different condition was met. Here the demand for the new building was not urgent. It was located in a small town where the capacity for caring for a large influx of workers was very meager. There were not sufficient boarding houses or hotel accommodations to handle more than a fraction of the number of men who would have been there for 3 or 4 weeks at the peak of the work. Rather than put the community to the inconvenience of arranging to accommodate these men for such a short period, a schedule was arranged which distributed the peak over a much longer interval and made use of many fewer men. The maximum number of men on the job was thus reduced by about 30%. Figure 31 illustrates how this worked out with regard both to the length of the peak and the number of men.

It will be noted, of course, that the number of man-days was approximately the same in each case, but the distribution of these work-units was different. There was a large element of policy in the arrangement for it was recognized that the manufacturer whose operation was a large part of the life of the community would continue to operate there for many years, and could not afford to upset the town by over crowding it with workers for the short period and then dropping them out completely.

From the above it will be evident that the mere question of dollars and cents is not always the answer, when economy is under consideration. The good will of the inhabitants of a small town may take precedence over need of manufacturing space to the extent of delaying a building for a month, as was the case above.

Colt's Plant Completed on Schedule Time.—*Engineering Record*, Feb. 3, 1917 describes the methods of construction of a large reinforced-concrete building for the Colt's Patent Fire Arms Manufacturing Company, of Hartford, Conn., which was carried out in accordance to the day with a previously published progress schedule. The builders, the Abertham Construction

Company, of Boston, did not reach this result by elaborate or unusual procedure, and but three months elapsed between the owner's decision to build and the completion of the four-story frame inclosing a floor area of 11.2 acres. Indeed, the only departure from the firm's customary practice in handling the work is stated to have been the advance publication of its progress schedule. The story of the planning and execution of this achievement is one of the application of hard common sense, with accuracy of detail but without delay of red tape, to the problem in hand.

By telephone appointment the contractors' engineers met the owners' representatives and the architects, Monks & Johnson, at Hartford on Monday, Aug. 21, 1916. The location and size of the building were there decided, and the conditions under which it should be built were arranged between the owners and the contractors. The work was undertaken upon a cost-plus-profit agreement, the same as on a previous building recently completed. The contractors became in effect the building department of the owners, bought all labor and materials, made all subcontracts and charged up everything at cost. For their executive services and profit they received a commission.

Plans and Work Start Together.—The architects immediately began on the plans, the contractors made up a probable square-foot-of-floor cost, began the clearing of the site and digging of test pits, and secured bids on footings and pile foundations. Coincidentally, after a quick but thorough survey of local conditions, such as the available vacant land, the railroad siding, the probable streets along which materials could be delivered, and nearby sources of materials that would be required, the engineering department made its first plant layout. Bins, sheds and office buildings were located and a place allotted for every class of material arriving on the job. This layout was subsequently perfected in the complete plan reproduced herewith.

At the next weekly conference of the contractor's staff the entire job was taken up for discussion and definite organization. At this conference were present the man who secured the contract, two general superintendents, the chief engineer, the purchasing agent and the schedule engineer. The manager, who usually presides, was absent. The building superintendent was selected, together with his principal assistants, the carpenter, labor and planning foremen, the engineer and the master

mechanic. The discussion covered plant layout, including number and location of mixers, method of distributing concrete, purchase and handling of lumber for forms, requirements in the way of steel and cement, prices and deliveries on these materials, architects' drawings, tentative progress schedule and many minor questions. Each man left the conference bearing definite responsibility for his part of the work.

The tests of the soil resulted in a decision to use piles, and the contract was given to the Raymond Concrete Pile Company. Two pile drivers were ordered on the job. In the shipping of one, which came from Boston, the Aberthaw company materially assisted their subcontractors in making quick time.

As a basis for all operations the schedule engineer immediately perfected his progress schedule, which is given in Table 10 in so far as it covers the direct work of the contractors.

Between the schedule engineer and the chief engineer the architects were kept informed as to dates upon which drawings must be in hand, and requirements in the way of form lumber, steel, cement, etc., were furnished to the purchasing agent. His responsibility ended when he had placed the order subject to specific deliveries. The superintendent on the job, being informed of the conditions of these orders, thereafter assumed responsibility for direct following up of the requirements. Any cases which he could not handle were referred back to the traffic department of the main office. Finally, cases which were beyond the power of the regular staff to straighten out were turned over to the manager to take up with the principal authority in the outside organization. In the case of subcontractors who were manufacturers, schedules were furnished and close touch was kept with the dates of beginning work and shipping the finished products ordered.

The situation was complicated by the New England freight embargo, but by having some source of supply or some method of handling always in reserve all serious delays were avoided. Plant, equipment, small tools and stationery scheduled by the building superintendent on a blank furnished for that purpose were immediately shipped. In accordance with the plant layout offices and storehouses were shipped from the contractor's yard, each building being made of standard sections 15 ft. wide in 10-ft. lengths.

The order for cement was placed, the storehouse was filled

TABLE 10.—PROGRESS SCHEDULE

Item	Start	Finish
Clearing of site	Sept. 4	Sept. 16
General excavation	Sept. 11	Sept. 20
Footing and foundation walls	Sept. 18	Oct. 5
Rolling for paving	Sept. 14	Sept. 25
Backfill and grading	Sept. 20	Oct. 5
Driving of piles	Sept. 14	Oct. 16
Test pits	Sept. 1	Sept. 16
Concrete		
Footings and foundation walls	Sept. 20	Oct. 7
Paving	Sept. 28	Oct. 10
Floors and columns	Oct. 6	Nov. 23
Stairs	Oct. 28	Dec. 7
Sills and coping	Nov. 7	Dec. 12
Parapet	Nov. 18	Nov. 25
Penthouse	Nov. 18	Nov. 25
Granolithic finish	Nov. 6	Dec. 9
Carborundum rub	Oct. 13	Dec. 5
Cinder roof	Nov. 18	Nov. 30
Unload cement	Sept. 7	Nov. 22
Unload sand	Sept. 16	Nov. 22
Unload stone	Sept. 16	Dec. 5
Unload, erect and dismantle plant	Sept. 2	Dec. 16
Steel Reinforcing		
Unload	Sept. 11	Oct. 14
Bend and place columns	Oct. 5	Nov. 22
Bend and place footings and walls	Sept. 16	Oct. 7
Bend and place floor	Oct. 5	Nov. 22
Bend and place beams	Oct. 5	Nov. 22
Bend and place miscellaneous parts	Oct. 5	Dec. 15
Forms		
Footings and foundation walls	Sept. 16	Oct. 8
Make columns, floors and bins	Sept. 25	Oct. 11
Erect columns	Oct. 6	Nov. 21
Erect floors and roof	Oct. 6	Nov. 21
Erect beams and slab	Oct. 6	Nov. 21
Erect wall beam	Oct. 6	Nov. 21
Erect parapet	Nov. 15	Nov. 29
Sills and coping	Nov. 6	Dec. 14
Stairs	Oct. 25	Dec. 14
Penthouse	Nov. 15	Nov. 25
Unload lumber	Sept. 5	Oct. 5
Strip columns	Oct. 13	Nov. 25
Strip slabs	Oct. 18	Dec. 5
Steel sash—Unload	Nov. 6	Nov. 18
Steel sash—Erect	Nov. 7	Dec. 12
Steel sash—Grout	Nov. 8	Dec. 16
Masonry		
Unload brick and tile	Oct. 16	Nov. 30
Lay tile	Oct. 30	Dec. 9
Lay brick	Oct. 25	Dec. 9
Staging and plant	Oct. 20	Dec. 13
Plastering	Nov. 6	Dec. 20
Door frames, guards and sills	Oct. 25	Dec. 10
Doors and hardware	Nov. 15	Dec. 16
Inserts	Oct. 9	Nov. 25
Sleeves	Oct. 9	Nov. 25
Scuppers	Oct. 9	Nov. 25
Miscellaneous iron work	Oct. 15	Dec. 15
Clean up job	Dec. 21	Dec. 30
Watchman	Sept. 14	Dec. 30
Overhead	Aug. 30	Dec. 30

in advance of requirements, continuous shipments from the mill were maintained, and arrangements made with a local dealer so that his stock could be drawn upon in case of emergency. Sand and gravel were contracted for locally and hauled from near-by banks, of which the number was sufficient to guard against a

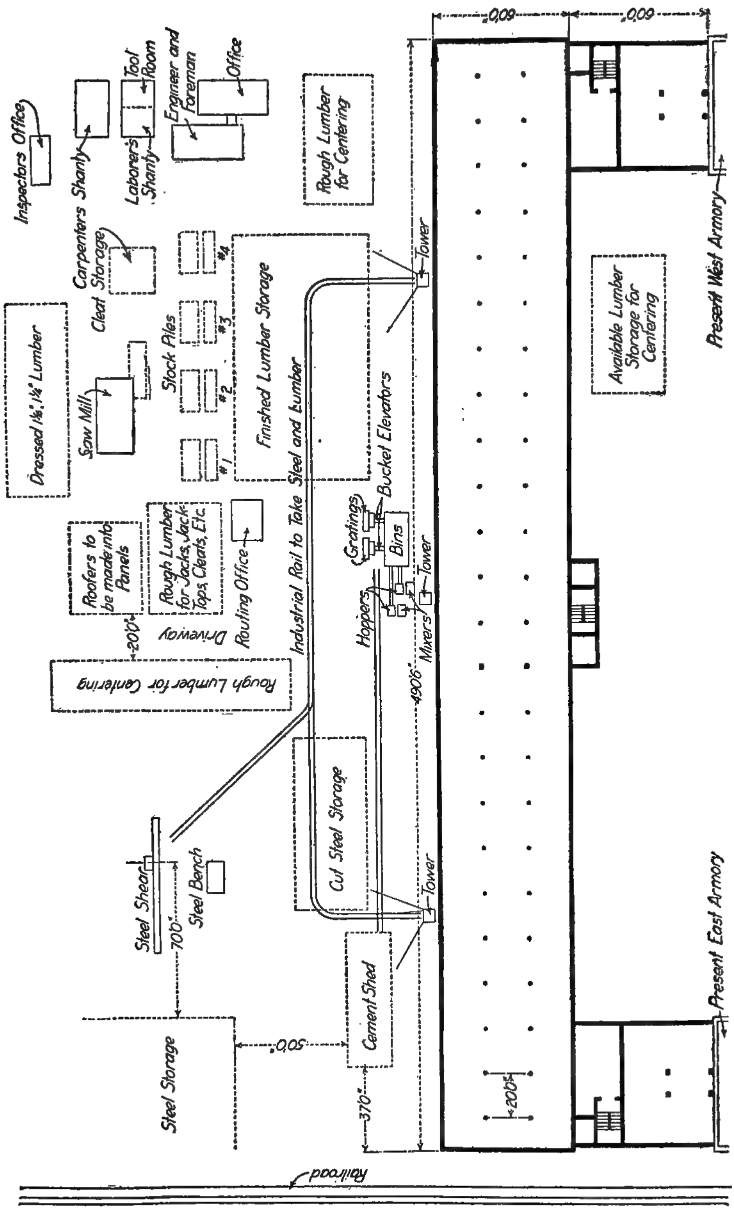


FIG. 32.—Layout adjusted to delivery routes, requirements of construction and space available.

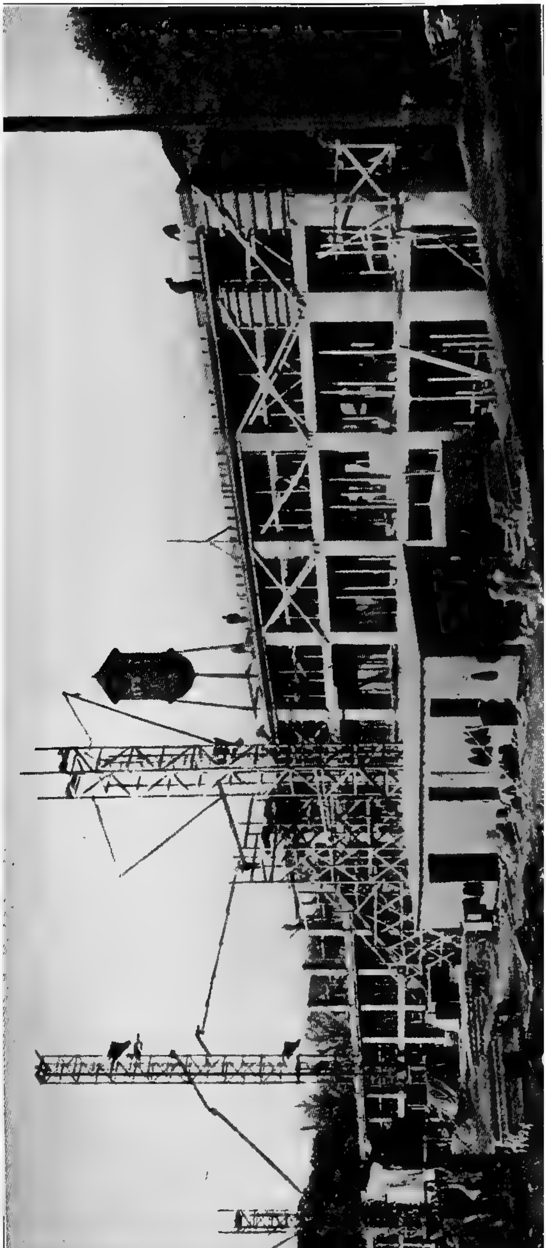


FIG. 33.—Photographs taken on dates given in announced progress schedule showed work advanced to specified levels.

tie-up with any one contractor. The storage bins were kept filled and daily deliveries made direct to the mixers. All scheduled form lumber, cut to dimensions, was turned out by a local mill, delivered on the job and piled separately according to size, ready for use. Because of the close proximity of the mill, and the fact that others stood ready to meet the requirements, daily deliveries were made and only a limited supply of lumber was kept on the ground.

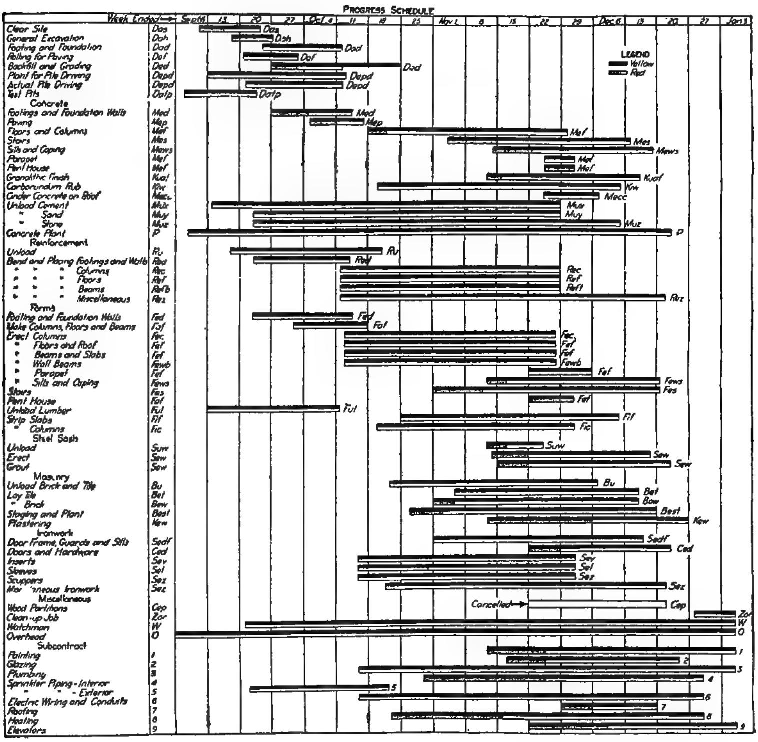


FIG. 34.—During progress of job vertical lines showed dates, while crayon lines represented quantity of work done.

To start the job reinforcing steel was shipped from the Aberthaw yard in Boston. With the exception of a few local emergency purchases handled by truck or auto there was no tie-up on account of steel, notwithstanding the freight embargo.

In the matter of labor the company's usual policy of transferring men from other jobs where they could be spared was maintained. Through the avoidance of hiring and discharging

on the job the contractor has been able to build up an organization in which even the members of the shovel brigade average 2 years connection, while concrete laborers, steel men and carpenters remain 3 and 4 years in the service of the company. A material factor in holding men together is the maintenance of the same rate of pay no matter where the man is at work. The number of men employed on the job on each of the principal dates specified in the construction schedule is given in Table 11. These are grouped according to the character of the work.

The chart, Fig. 34, graphically represents the dates and limits and served as a basis for recording progress. Three blueprints of it were sent to the job, one for the superintendent, one for the routing department and a third to be brought up to date weekly and sent to the Boston office. Another copy was kept on the bulletin board in the Boston office, and was brought up to date weekly from the copy sent in by the job. On the blank blueprint each item of work was represented by a wide white line. When an item of work was started it was recorded on the sheet

Table 11.—Men Required by Schedule

	Oct. 6	Oct. 21	Nov. 2	Nov. 13	Nov. 23
Laborers (including steel men)	83	79	109	96	90
Labor foremen	7	7	9	8	5
Carpenters	17	31	44	46	28
Carpenter helpers	26	42	73	81	49
Carpenter foremen	5	6	6	6	6
Master mechanics and mechanics	9	16	14	15	15
Cement finishers	..	6	16	14	16
Masons and tenders	..	..	8	9	18
All others	18	21	12	25	21
Totals	165	208	291	300	248

by drawing a yellow line over the upper half of the heavy horizontal line. The length of the yellow line was made proportional to the amount of work done on that item, the entire heavy line representing volume rather than time, although it spans the period between the scheduled beginning and ending. It is

therefore evident that the ratio of the length of the yellow line to the total length of the heavy line represents the proportion of the particular item of work which had been completed.

In operating such a chart, when work does not start on time a red line is drawn over the lower half of the heavy white line and is continued to the date when the work starts, when the yellow line is begun in its proper place. The red line therefore shows at a glance just how far behind work is upon the given item. Each week a piece of string is stretched vertically across the chart from the current date shown at the top of the sheet. If at any time the yellow lines extend beyond this string it indicates that the job is ahead of schedule on that particular item.

"Finished to Schedule."—Unusual attention was directed to the building by the advance publication of the proposed construction schedule and the issuing of periodic bulletins showing by photographs how it was being met floor by floor. Although the complete schedule was detailed nearly ten weeks in advance of the date of pouring the roof, the suggestion of publishing it was not made until some time later. Instructions were then given that work was to proceed exactly as on any other job. The principal dates in the construction schedule as published were as follows:

Oct. 6	Start superstructure
Oct. 21	Finish pouring concrete, second floor
Nov. 3	Finish pouring concrete, third floor
Nov. 13	Finish pouring concrete, fourth floor
Nov. 23	Finish pouring concrete, roof

After making the usual allowance for stormy weather the schedule showed 42 working days for completing from foundations to roof the four-story concrete building, which is 490 by 60 ft., with a 60-ft. square wing at each end, and has a plan area of 2.8 acres. Although the work was actually completed in 40 days, this was not due to speeding up, but merely to the fact that the anticipated number of stormy days did not materialize. In a word, the schedule was met to a day so far as the actual working period was concerned.

Progress and Cost Chart.—Figure 35 is of another type of progress chart. This chart shows the labor, material and total costs both actual and estimated, together with the number of units of material placed.

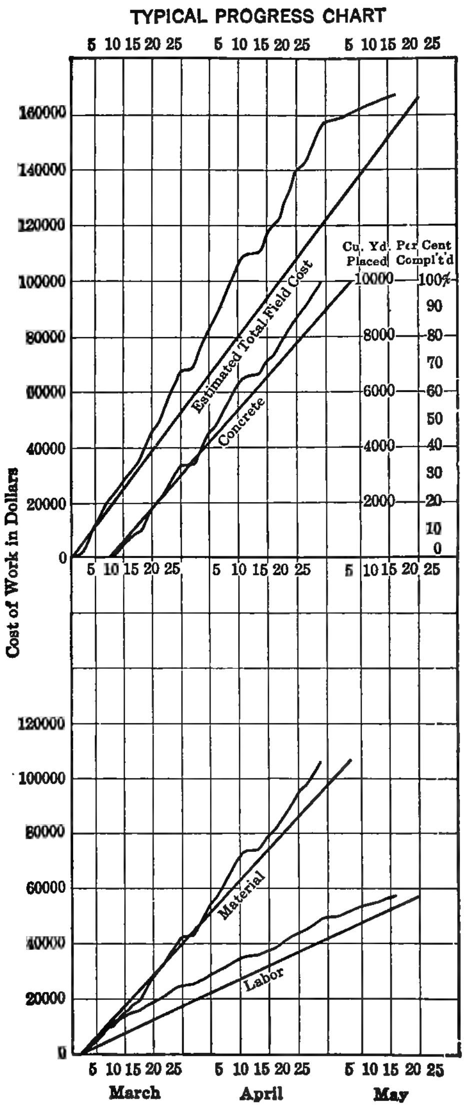


FIG. 35.—Progress and cost chart on concrete retaining wall.

With such a chart it is evident that at any date the following items may be seen:

1. Total quantity of material placed.
2. Cost of labor, material and total cost.
3. Days of lost time by counting the number of days that material line runs horizontal.
4. The progress of the work-percentage completed to date.
5. Percentage of work done from one date to another by subtracting totals of the two dates.

CHAPTER VI

COST KEEPING AS APPLIED TO HIGHWAY CONSTRUCTION

The material of this chapter is abstracted from *Bulletin* 660 of U. S. Dept. of Agriculture, entitled "Highway Cost Keeping," by J. J. Tobin and A. R. Losh, and reviewed by one of the authors of the present work. Besides some extremely practical material that applies directly to highway engineering, it covers some very sound and interesting matter pertaining to all cost keeping in general.

THE FUNDAMENTALS OF COST KEEPING

Definition.—Cost keeping is a system for recording the cost of each unit of product or division of work in order to facilitate comparison of such costs with cost of other similar units or divisions under like conditions. Cost keeping analyzes each unit of product or work to determine the reasonableness or unreasonableness of the cost, and also to secure an intelligent basis for predicting the cost of producing similar units in future.

Lack of Cost Records.—The Office of Public Roads and Rural Engineering, in an extensive investigation of highway management, both by the State highway departments and by a large number of individual counties and townships, brought out, among other conditions, the very general absence of cost keeping. Few examples of practical and efficient cost keeping were found in operation, and these were confined largely to the State highway departments. Only in rare instances were cost-keeping systems found in counties or townships. This condition is due largely to the notable scarcity of information available on the subject of highway cost keeping, as practically all textbooks on cost keeping have been prepared from the viewpoint of factory management and are not readily adaptable to highway work. Furthermore, the usefulness of highway cost data has not yet been generally appreciated by public officials.

Purpose of the Bulletin.—The purpose of this publication is to present, first, in an elementary way the principles which govern

cost keeping; second, a practicable application of those principles to highway work.

Development of Cost Systems.—Cost keeping was developed in the manufacturing industries. To Charles Babbage has been conceded the honor of having first called the attention of the manufacturing world to its desirability, in 1832, in his publication entitled "The Economy of Manufacture." Half a century elapsed, however, before factory managers, forced by relentless competition to eliminate waste and incompetency from their factories, began to introduce systems of cost keeping.

Since 1900 the use of cost keeping in manufacturing industries has developed steadily. During this period of development principles regarded as basic have been established. While cost keeping for highway work is of comparatively recent origin, it is based upon factory cost keeping, and the same principles govern.

COST ELEMENTS

The term "cost," as generally interpreted and as used in this bulletin, is the summation of expenditures expressed in terms of money involved to acquire or produce a utility or to perform a service.

The cost of every unit of product, whether it be a square yard of road surface maintained, or a cubic yard of concrete which is a part of a bridge or culvert, is composed of four basic elements of expense, namely:

1. The cost of labor.
2. The cost of materials.
3. The cost of service of plant and equipment.
4. The cost of general expense or overhead.

Labor.—The costs of labor are divided into two classes; first; direct labor cost; and, second, indirect labor cost. All labor chargeable against the product which can be designated as directly expended on it is called direct labor. All labor chargeable against production and not directly expended on the product is called indirect labor. For example, the cost of men using picks and shovels on excavation who are directly expending their efforts on that piece of work is a direct labor charge. A superintendent in charge of a road job is not directly expending labor on excavation, but is engaged in directing the prosecution of all kinds of work and his expense is an indirect labor charge, chargeable

pro rata against the production of all the work units he may be supervising. Other examples of indirect labor are the services of watchmen, timekeepers, and water boys.

Materials.—Materials also are divided into two similar classes —direct and indirect. All materials entering the product as an integral part of its composition are called direct materials. All materials chargeable against the production but which do not enter directly into the product as an integral part of it are called indirect or expense materials or sometimes supplies. The cement, stone, and sand that are mixed together to form the concrete of which a concrete road is constructed are all direct materials, but the oil used for lubricating and the gasoline for operating the mixer in which these materials are prepared for use are indirect materials or supplies. It is easy to charge direct material cost, but often it is very difficult to charge to each product its correct share of indirect material cost.

Small, or hand, tools not used as a part of some plant unit and which have such a short period of usefulness that they are seldom used on more than one job, usually are considered supplies and therefore are part of the indirect materials charged to the work.

Plant and Equipment.—"Plant" includes such physical property used on the work as land, structures, machinery, live stock, and tools of a more permanent character than those referred to as supplies. "Equipment" is a less inclusive term and is interpreted generally to mean the smaller and especially the movable plant units. The cost of the service of "plant" can be charged most readily in the form of a daily rental against the work upon which it is used. This rental should be charged whether the equipment be owned by the operating organization or leased from other owners. It consists of "operating charges," which are—

(*a*) The expense of operation,
(*b*) The average cost of repairs,
(*c*) Charges for the time spent in idleness,

and "fixed charges," which are—

(*d*) Charges for depreciation,
(*e*) Interest,
(*f*) Taxes,
(*g*) Insurance.

The Expense of Operation.—This includes the wages of operators and helpers and the cost of supplies during the periods of operation. Usually these are charged directly against the work

done and not included in the plant rental. It is only necessary that they be charged in one place or the other, and it is important to specify what is included in rental when leasing equipment.

The Average Cost of Repairs.—There is a difference of opinion among cost accountants as to how repairs and renewals to plant should be charged. One view is that renewals may be of such a nature that the useful life of the machine has been increased and therefore the expense of such renewals should be looked upon as an offset to depreciation. Another view is that there is no difference between repairs and renewals, except in degree, and that they all should be considered in the same light; *i.e.*, independent of depreciation charges. It appears that the latter consideration permits simpler accounting and does not rely so much upon individual judgment as to whether the expenditure is for repairs or for renewals.

After a machine has been rebuilt or repaired extensively with the intention of increasing its serviceable life, it should be considered as a piece of new equipment valued at its depreciated value, plus the cost of renewals. This necessitates the computing of a new rate of depreciation on the basis of the new value and assumed new useful life.

The approximate average cost of repairs, including extraordinary repairs, often can be arrived at by casting up old accounts and finding what a similar piece of machinery used on similar work has cost for repairs over a term of years.

Charges for Time Spent in Idleness.—To arrive at a fair and equitable daily charge for rental some allowance must be made for time spent in idleness, because on these days the fixed charges still are continuing and certain supplies are necessary even though the machine be not in operation. The usual way of arriving at the charge for lost time through idleness is to bring together all of the charges for a year and divide them by a number of days the machine actually was in use. By dividing the sum total of expense by the number of days the machine was available for use even though no work existed on which it could be used, the result would be a daily rental with no allowance for lost time. The difference between these two rentals will show what a considerable factor in the fixed charges this item of lost time may become. In all contracts or agreements on rental of equipment care should be taken to specify whether the rental is "per day" or "per day of service."

Charges for Depreciation.—Equipment is consumed in production just as truly as material. This loss is called natural depreciation. Depreciation may be either natural or functional. "All equipment progresses steadily toward the scrap pile, starting the date it is purchased, and while its progress may be delayed it can not be prevented by repairs."[1] It is as much an expense on a steam roller as the cost of fuel burned in the firebox. In the case of fuel the expense is immediate; in the case of depreciation the expense is extended over a period of time. Functional depreciation is loss due to the obsolescence or inadequacy of equipment.

There is no doubt in the minds of cost accountants that depreciation of plant and equipment should be included as a charge against operation, but there is considerable difference of opinion as to how depreciation should be computed.

Three factors determine in all cases what the depreciation should be: First, the original cost; second, the length of useful life; and third, the scrap value of the machine when it no longer can be used for the purpose for which it was purchased, or the salvage value, if it is to be considered as a "second-hand" piece of equipment. Knowing these factors, the problem resolves itself into how to divide the difference between the original cost and the scrap or salvage value (called total depreciation or wearing value) over the length of the useful life of the machine. A number of formulas have been devised for computing decrease in value or depreciation. Fish, in his textbook on "Engineering Economics," explains five such formulas. Three of the more commonly used are the straight line, the declining balance, and the sinking fund.[2]

The first is recommended as the simplest and perhaps best method for road work. By this method the total depreciation is divided by the number of years of useful life and the quotient charged off as a yearly depreciation. This is called the straight-line method, and its greatest advantage is its extreme simplicity.

The second method, a modification of the straight-line method, is called the declining balance method. It is based on the theory that during the earlier years of the life of any machine the repairs are smallest, and therefore to arrive at a constant charge for repair

[1] "Modern Accounting," H. R. HATFIELD.

[2] The "Unit Cost Depreciation Formula," which is the only one that is perfectly general and theoretically correct, is given in the Handbook of Mechanical and Electrical Cost Data by Gillette and Dana.

and depreciation, the depreciation must be heaviest in the earlier years of the life of the machine and lightest in the last. The plan, therefore, is to charge off a fixed percentage annually from the net value of the machine. This gives a diminishing annual charge for depreciation. In the comparative table (page 224) this annual rate is about 30 %. This is determined by the formula $r = 1 - \sqrt[n]{\frac{v_2}{v_1}}$ in which r is the percentage of diminishing value, n the life of the equipment in years, v_1 the original value, and v_2 the scrap value.

COMPARISON OF DEPRECIATION FORMULAS

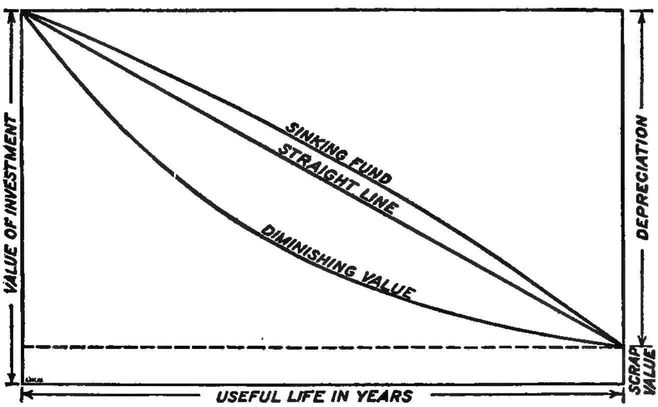


Fig. 36.

The third method is called the sinking-fund method. It is based on the assumption that the depreciation on a structure at any time is equal to the accumulations of a sinking fund established for renewal at the end of its useful life. The depreciated value plus this sinking fund (actual or imaginary) at any period equals the original cost.

It should be observed that none of these formulae takes into consideration interest on investment, output, cost of operation, or maintenance charges. Figure 36 gives a graphic comparison of the above formulas.

The following table is a comparison of the annual depreciation on a $600 machine that has an assumed useful life of 5 years. It also is assumed that at the end of this period it will have a scrap value of $100. The annual depreciation is computed by the three formulas described:

TABLE 13.—COMPARISON OF THREE METHODS OF COMPUTING DEPRECIATION

Years	Straight-line method	Diminishing-value method	Sinking-fund method, 6 % interest
First	$100	$180.72	$88.70
Second	100	126.28	94.02
Third	100	88.25	99.66
Fourth	100	61.67	105.64
Fifth	100	43.08	119.98
Total	500	500.00	500.00

The theory of natural depreciation, epitomized, is that all equipment, even if kept in the best of repair, in time will reach a state where repairs no longer are sufficient to keep it in economical working condition and the entire machine must be renewed. The fund created by the depreciation charges is intended to supply the money to purchase a new machine to take the place of the one expended, or to retire the original investment in case the machine no longer is needed.

Any of the depreciation formulae is satisfactory in determining rental charges, provided the assumed life of the machine be approximately correct. As the assumption of the useful life of the machine may be the source of considerable error, there seems to be little argument for the finer calculations as to methods of distributing the depreciation.

It will be found convenient in computing depreciation to group elements of the plant having approximately the same serviceable life. This will have the advantages of requiring fewer accounts and tending to equalize high and low assumed machine life.

Repairs and renewals are charges due to breakage or the wearing out of expendable parts of equipment. It is obviously incorrect to charge to repairs or renewals any improvements or betterments added to any piece of equipment. When such improvements have been made the cost should be added to the present value of the machine and a new depreciation computed upon this new value. An example of such a case would be the addition of a conveyor to an old stone crusher for the purpose of doing away with shovelers. The improvement is not a repair of any broken parts or a renewal of any part worn out by the

continual use of the machine; it is a new feature which adds to the value of the crusher. A rebuilt second-hand machine may be considered in the same light.

Interest, Taxes, and Insurance.—Interest should be charged on the investment at the rate paid or the prevailing rate, where there is no indebtedness.

Taxes, as paid, should be charged in the rental rate.

Insurance should be charged either as paid or at the prevailing rates if the organization carries its own risk.

General Expenses.—The fourth element of cost is general expense. It often is called "overhead" or "burden," terms derived from factory cost keeping, the use of which in highway-cost keeping is not recommended.

General expense includes all charges that can not be connected directly with the cost of labor, material, and plant. For convenience in accounting and for the purpose of securing a desirable division of road cost, general expense will be considered as divided into two classes. One will be referred to as "engineering and supervision" and will include those items of inspection and engineering which can be charged directly to the project. The other class will be referred to as "administration expense" and include those expenditures incurred in conducting all the activities of the department which are so general in character that they are not assignable directly to any particular project.

The desirability of separating the project cost of engineering and supervision from administration cost and unit costs will be apparent after a little consideration. The work of the engineer in preparing the plans and specifications affects labor and material costs only in the kinds and amounts that may be required and not at all in the efficiency of their expenditure. By carefully worked out profiles and cross-sections an engineer may reduce the yardage of excavation required, but such planning may not reduce the cost per unit of excavation. To secure efficiency in operations in the function of the superintendent or the foreman who is responsible for the cost of such operations. If engineering and supervision cost is incorporated in unit cost, an element is included over which the foreman or superintendent has no control, and his efficiency is obscured thereby. If, on the other hand, engineering and supervision cost is included in the charge for administration, it is placed in a class of expenditures over which the engineer has little or no control.

Highway administrative organizations are prescribed largely by statute and the attendant costs necessarily are dependent, in a large measure, upon the form of the organization, the various duties required, the methods of financing, and many other factors, all of which are conditions imposed by legislation. To include with these administrative costs the cost of project engineering and supervision would mean the loss of valuable comparable information on the efficiency of the divisions of an organization and one type of administrational organization with another.

Administration.—Administration costs include such expenditures as salaries and expenses of the executive officers, legal services, maintenance of office, departmental engineering, investigations, experiments, clerical staff, fiscal operations, and miscellaneous fixed charges. These expenditures can not be allotted directly to any particular class of work or to individual projects.

Cost accountants have devised numerous ways of distributing general expenses to the various classes of work. Most of these, however, are not practicable in the distribution of such expenses on road work. Since indirect labor and indirect materials are distributed directly in the unit costs, and engineering and supervision are chargeable directly to projects, the remaining portion of what would be considered "burden" by factory cost accountants is comparatively small in proportion to the aggregate expenses. Any portion of general expense that can be assignable directly to a project should be charged against such project. The remainder should be prorated over all the project expenditures for the period.

Engineering and Supervision.—To engineering and supervision should be charged all expenditures for surveys, plans, specifications, estimates, tests, and all engineering inspection and supervision in the nature of oversight required to secure the proper execution of the work. Such expenditures can be charged directly to individual projects.

Fixed Charges.—Fixed charges are those items of expense which go on practically unchanged irrespective of the activities of the organization. Those fixed charges which pertain to the production plant have been discussed in relation to plant and equipment. Certain fixed charges not immediately connected with production operations may best be considered as a part of general expense. Thus depreciation, interest, taxes, and insur-

ance are elements of expense also in relation to the plant and equipment of the administrative organization, such as buildings, office and laboratory equipment, instruments, machines, and similar items.

In the practical application of cost keeping, fixed charges are considered only in so far as they aid in the determination of efficiency, and their inclusion as an item of cost is a question of accounting. Where fixed charges result from methods of financing rather than the methods of doing the work they belong to the field of bookkeeping and not cost keeping. Thus, where a county issues bonds for road improvement the interest is a fixed charge which must be paid and so increases the total outlay for the improvement but has no relation to the efficiency with which the work is executed, and is, therefore, a matter of bookkeeping and not cost keeping. Where two crews are engaged in excavation, one with power tools and the other with hand tools, fixed charges are of prime imporance to the cost keeper for the purpose of determining efficiency and the cost of operation in each case.

It is customary among contractors to include all fixed charges as a part of the expense of work, and therefore they appear in the unit prices of their itemized bids. In making up his estimates on unit prices to check against submitted bids, the engineer therefore should include among other fixed charges interest on capital invested in plant and on necessary operating capital, for materials pay roll, and deferred payments.

Considerations of fixed charges are also important in the selecting of equipment and determining upon types of improvements. These considerations are, however, within the field of engineering economics and not cost keeping, although cost data have a most important part in the final determination.

HIGHWAY COST ANALYSIS

An analytical chart has been prepared to place before the reader in concise and convenient form a summary of the foregoing discussion of cost elements applied to road work, and to show the relation between the cost elements and the final cost of the project as expressed in totals and by units. The first column of the chart contains the four basic elements of cost. Opposite each element, in the second column, are the classes of expenditure, such as direct, indirect, etc. The third column shows in detail

Highway Cost Analysis

	Elements of cost	Classes of cost	Application of cost	Product of cost	Summary of cost
Highway cost..	Labor cost.............	Direct..................	Wages of laborers, mechanics, teamsters, etc.	Construction, maintenance, or reconstruction of road parts, right of way, grade and roadside, roadway, ditches, drains, bridges, and culverts, and supplementary parts.	By units, direct as performed.
		Indirect................	Wages and expenses of superintendents, foremen, timekeepers, guards, watchmen, water boys, etc., lost labor days, labor expense.		
	Material cost...........	Direct..................	Materials entering into product as integral parts.		
		Indirect................	Supplies, used but not as a part of product.		
	Plant and equipment service cost.	Operating...............	Operation. Repairs. Idleness.		
		Fixed...................	Depreciation. Interest. Taxes. Insurance.		
	General expense cost....	Project: Engineering and supervision.	Salaries and expenses of engineers, field parties, draftsmen, inspectors, and clerks; office expenses, tests, and miscellaneous expenses for individual projects.	Plans, specifications, estimates, surveys, inspection, and direct supervision of work.	By project; upon completion may be approtioned to units.
		General: Administration...	Salaries and expenses of executive, engineering, legal, and clerical staffs; expense of office maintenance, experiments, investigations, and fiscal operations: miscellaneous fixed charges.	General direction, policy, oversight, planning, control, legal and financial provisions.	On all operations over a period of time and apportioned to projects.

the specific application of the cost. Example, "for materials," "for labor," "superintendence," etc. The fourth column contains a tabulation of the class of product resulting from the cost outlay, such, for example, as construction, maintenance, right of way, etc. The fifth column contains the final cost and presents it by units, by project, etc.

Units of Measurement.—Care should be taken in selecting the units on which to collect cost data. Too many and varied units will make the system cumbersome and expensive, while too few may impair its value seriously. Furthermore, the units of measurement adopted for any cost-keeping system or project must be definite, expressive, readily obtainable, and familiar. Thus, for example, the ton and the cubic yard as applied to broken stone are definite units and afford a ready and accurate comparison, but the square yard when applied to a finished macadam road is indefinite until additional information as to the depth of the material is available. Similarly, many units, such as wheelbarrow, wagon, truck, or carload, while often convenient units of count in the field, are indefinite and always should be reduced to definite comparable units, such as cubic yard or ton.

The units selected must, so far as possible, be expressive of definite operations. Thus, while in engineering construction the cubic yard is a very common unit upon which contract prices are based, it frequently is a very uncertain unit of performance, as it is a composite of other units. For example, in rock excavation there are involved the following operations: (1) Drilling, (2) blasting, (3) breaking large chunks, (4) loading into carts, wagons, cars, or the like, (5) transporting, (6) dumping.

The important item of drilling depends largely on the necessary spacing of the drill holes, which varies in the different kinds of rock and in different kinds of excavation. Clearly, then, the linear foot of drill holes is the unit for measuring the output of the drillers, and not the cubic yard. Transporting the rock is largely a function of distance; hence the unit of transportation cost should be the ton or yard carried 100 ft. or 1 mile, and not the cubic yard without the factor of distance.

The units must be obtainable readily or the cost of collecting the necessary data will be too high. Thus, for example, to obtain the exact cubic yardage and the distance it was moved in preparing the subgrade for a macadam road with a road machine would be not only difficult but expensive. Hence for this class of work

the readily obtainable, though less definite, unit of the square yard usually is adopted.

That the full value of the cost-keeping system may be realized, the units in which the data are expressed must be familiar to those charged with their collection as well as to those who are to profit from their use. Thus, the cubic meter is as definite a unit for measuring earthwork and generally as readily obtainable as the cubic yard, but to the average roadman it has little or no meaning until translated into the terms in which he is accustomed to think. If any one of two or more units otherwise would answer equally well, the one most familiar and generally used always should be adopted.

There are many units so closely related to the desired unit of measurement that with very little computation they can be transformed into the desired unit. For example the knowledge of the number of bags or barrels of cement used and the proportion of the mixture of the concrete are functions which at once determine the amount of sand and stone used. A number of tables giving some of the more common and convenient units of measurement used in collecting and compiling cost data relating to road work are given in the Appendix.

Essentials of a Cost System.—Certain fundamental principles must be followed to make any cost system successful. This applies to road costs as well as to factory costs. Any cost-keeping system to be successful must be (1) reliable, (2) simple, (3) immediate, (4) flexible, and (5) relatively inexpensive.

1. Reliability is of paramount importance. If the data collected are not reliable, all records based upon them of course will be misleading and the results dangerous. Accuracy is desirable, but this need not be carried beyond the practical limits adopted for measuring the units of materials expended and the units of work accomplished.

2. If simplicity be not maintained the purpose of the system will be defeated. Involved and complex forms are confusing to the recording officials, difficult to compile for study and analysis, and apt to be inaccurate and a useless expense.

3. To be effective, the cost records must be susceptible of immediate analysis and must reach the officials responsible for the economic progress of the work in time to be of use. If a week or 10 days must elapse before wasteful methods and incompetency are discovered the information is past history and it may be

too late to try other methods which might rectify the detrimental condition.

4. Flexibility is very desirable. The system must be elastic enough to provide for the recording of all classes of work, irrespective of the size of the project, without any material change in the prescribed forms.

5. Finally, the system must be relatively inexpensive. The cost of determining cost must be reduced to a minimum. If expense of obtaining cost records to point out the way to efficiency is not much below the saving effected, they have no just claim to a place in any plan of management.

Classification of Expenditures.—The first problem in developing a cost-keeping system for highway work is to devise a general classification of expenditures that will conform to accounts appearing upon the ledger of the organization; that is, at the outset the cost keeper's records must tie into the bookkeeper's accounts. The ledger, it is well to recall, contains only as debits the funds received or appropriated and as credits the payments made from those various funds summarized from a record which carries the distribution of these expenditures according to subheadings or primary accounts. It is usual to classify accounts as far as possible by departments, or with respect to certain functions for which funds are provided. Such a classification of accounts provides the first division for the cost keeper. This division gives what usually are known as the general accounts. Numbers or letters are used to represent these accounts, and in these letters or symbols we have the beginning of a code for cost keeping. The following classification and corresponding letters show a departmental division of accounts and a letter code suitable for highway work:

GENERAL ACCOUNTS

C. CONSTRUCTION.—M. MAINTENANCE.—R. RECONSTRUCTION.—
P. PLANT—A. ADMINISTRATION.

The first three of these, it will be observed, have to do with certain road operations. It will be found upon analysis that they consist of the operations necessary to produce or preserve road parts. A subdivision of these general accounts produces what are called the primary accounts. Such a division is shown below. The accompanying numbers give a development of the cost-keeping code:

C, M, and R. Construction, Maintenance and Reconstruction

00 to 09. Right of way.
10 to 19. Grade and roadside.
20 to 29. Roadway.
30 to 39. Ditches and drains.
40 to 49. Bridges and culverts.
50 to 59. Supplementary parts.
60 to 69. Engineering and supervision.

P. Plant.

70 to 79. Plant accounts.

A. Administration.

80 to 99. Administration accounts.

The numbers preceding the primary account give the range of class numbers for the final cost-keeping code. Thus 30 to 39 are the inclusive numbers for class costs of ditches and drains. This first division of the general accounts would serve very satisfactorily for a simple cost-keeping system. In such case the first set of numbers could be omitted and ditches and drains would be represented by 39 instead of the range of numbers from 30 to 39.

To obtain a system of class numbers for more detailed costs these primary accounts are further expanded as shown in the following table:

Primary Accounts and Class Code

C, M, and R. Construction, Maintenance, and Reconstruction

Right of Way

00 Preliminaries.
01 Right-of-way surveys.
02 Right-of-way plans.
03 Real estate.
04 Damages.
09 Miscellaneous.

Grade and Roadside

10 Cuts and embankments.
11 Shoulders.
12 Berms and slopes.
13 Trees, shrubs, grass, etc.
19 Miscellaneous.

Roadway

20 Subgrade.
21 V drains.
22 Sub-base.
23 Base course.
24 Intermediate course.
25 Binder course.
26 Cushion course.
27 Top course.
28 Surface.
29 Miscellaneous.

Ditches and Drains

30 Ditches and gutters.
31 Ditches and gutters, paved.
32 Blind drains.
33 Tile drains.
34 Catch basins.
35 Drainage channels.
39 Miscellaneous.

Bridges and Culverts

40 Foundations.
41 Abutments.
42 Piers and bents.
43 Superstructures.
44 Box culverts.
45 Pipe culverts.
49 Miscellaneous.

Supplementary Parts

50 Signs and sign posts.
51 Monuments.
52 Guard rails.
53 Curbs.
54 Retaining walls and parapets.
55 Riprap and revetments.
56 Roadside treatment.
59 Miscellaneous.

Engineering and Supervision

60 Location and relocation surveys.
61 Surveys (for operations).
62 Plans.
63 Specifications and contract preparation.
64 Estimates.
65 Expense of awards.
66 Office expenses, engineering.
67 Supervisory engineering.
68 Inspection and tests.
69 Miscellaneous.

P. Plant and Equipment

70 Buildings, fixtures and grounds 71 Quarries, pits, material yards, etc. 72 Power tools and equipment. 73 Hand tools and equipment. 74 Livestock and vehicles 75 Camp equipment. 76 Camp buildings and shelters. 77 Storage and transportation. 79 Miscellaneous.	Primary accounts.

A. Administration

80 Executive 90 Maintenance of office. 92 Legal. 94 Clerical. 95 Fiscal. 97 Engineering, departmental. 99 Miscellaneous	Primary accounts.

Note.—It will be observed that no divisions beyond primary accounts have been provided under Plant and Administration. These can be expanded further to meet the requirements of the organization.

Operation Code.—The next step is to develop a series of operations and a corresponding code which will include all the operations performed by the various departments to construct and maintain the works under their supervision. This may be accomplished in either of two ways. One is to list with each class of work all the operations that are performed under it. The other is to designate an operation by symbol and prefix this symbol with a class symbol, designating the class of work. By the first method such an operation as "rolling" would be listed under each roadway part and for both construction and maintenance. In the latter method, which is followed in this bulletin, "rolling" occurs only once in the operation code and the class code symbol is prefixed to give it the distinguishing classification. Thus any work can be indicated by combining a class code symbol and an operation code symbol.

The operation code consists of a list of descriptive phrases arranged alphabetically and designated by consecutive numbers following a dash or decimal point. This dash or decimal shows the linking together of the classification and operation codes. The operation code must include all operations necessary to be performed and the phrases must be limited to a single interpretation. The divisions of the primary and general accounts given previously form the class code. As these class code numbers

represent road parts or departments of the organization, an accumulation of a number of operations for any particular road part or department is effected readily by grouping all of those having the same class number. Below is given a typical operation series for the general operations of construction, reconstruction, and maintenance of highways. A similar code could be devised for other operations.

The Operation Code

–00 Assembling.
–01 Back filling.
–02 Blacksmithing.
–03 Blasting.
–04 Building.
–05 Building false work.
–06 Cleaning.
–07 Clearing.
–08 Clearing and grubbing.
–09 Cofferdamming.
–10 Cribbing.
–11 Curing concrete.
–12 Crushing.
–13 Dragging.
–14 Drilling.
–15 Drilling and blasting.
–16 Excavating borrow.
–17 Excavating common.
–18 Excavating earth.
–19 Excavating loose rock.
–20 Excavating solid rock.
–21 Excavating wet earth.
–22 Filling ruts.
–23 Filling washouts.
–24 Finishing.
–25 Forming.
–26 General.
–27 Grouting.
–28 Grubbing.
–29 Guarding.
–30 Harrowing.
–31 Hauling.
–32 Heating bituminous materials.
–33 Heating materials.
–34 Laying.
–35 Loading.
–36 Loading and hauling.
–37 Loosening.
–38 Mixing.
–39 Mixing and placing.
–40 Moving.
–41 Operating.
–42 Oiling.
–43 Painting.
–44 Patroling.
–45 Pile driving.
–46 Placing materials.
–47 Placing steel.
–48 Planting.
–49 Plumbing.
–50 Plowing.
–51 Pumping.
–52 Quarrying.
–53 Removing snow.
–54 Repairing.
–55 Riveting.
–56 Rolling.
–57 Scarifying.
–58 Screening.
–59 Shaping.
–60 Spreading bituminous materials.
–61 Spreading materials.
–62 Spreading screenings, sand, or chips
–63 Sprinkling.
–64 Stripping.
–65 Tamping.
–66 Trimming.
–67 Washing.
–68 Washing and screening.
–69 Wasting materials.
–70 Water-proofing.
–71 Working on joints.
–72 Wrecking.

Method of Obtaining Class and Operation Number from Code.—To procure a code number for any unit of work it is first decided what class of work is under consideration, and a number is selected from the class table. Then the specific operation is sought for in the second, or operation, table. The two are joined together with a hyphen or dash. The code letter of the department then may be prefixed to the first number and the classification symbol is complete.

If it be desired to know the code numbers to be used for recording the labor of a man mixing concrete for use as a road top course the class number for a road top course first is looked up in the class code (page 232). This number is found to be 27; then the operation "mixing" is taken from the operation code (page 234) and found to be 38. Joining the two together with a dash produces the full code symbol 27–38. The letter "C" prefixed would indicate construction work, while the letter "M" would indicate a maintenance operation.

Usually no classification letter will be used, but instead the capital letter "C," "M," or "R" will be shown on the recording form. If it be desired to know what code symbol to use in order to indicate properly the time of a man spreading bituminous material on a road for maintenance purposes, the letter "M" is set down first to show that the work is that of maintenance. From the class code (page 232) the number for a surface is found to be 28. Preceding this number with a capital letter "M" give M–28, which shows that maintenance work has been done on a road surface. Then there is selected from the operation code (page 234) the number for spreading bitumen, which is found to be 60. The code symbol for maintenance work of spreading bitumen on a road surface then will be M–28–60.

Use of Code in Operations.—In actual use the cost keeper generally would obtain his data from the timekeeper, who would be charged with keeping time and costs. A code for use of the timekeeper would be prepared from the class and operation codes, which would have the advantage of being abbreviated and also properly arranged for the cost keeper's needs. Below is shown such a code, which was used on work where costs of the principal operations were desired, and also the expanded code, which was used where it was desired to make a more detailed study of operations for the purposes of efficiency.

TIMEKEEPER'S CODE

ABBREVIATED	EXPANDED
(1)	*Grade and roadside.*
19–17 Grading—rough.	11 Shoulders:
	–56 Rolling.
	–58 Shaping.
	19 Miscellaneous:
	–07 Clearing.
	–16 Excavating borrow.
	–17 Excavating common.
	–19 Excavating loose rock.
	–20 Excavating solid rock.
	–28 Grubbing.
	–31 Hauling.
	–35 Loading.
(2)	*Roadway.*
20–59 Grading—fine.	20 Subgrade:
	–56 Rolling.
(3)	–59 Shaping.
23–26 Base course—general.	–63 Sprinkling.
	23 Base course:
(4)	–12 Crushing.
23–34 Base course—laying.	–31 Hauling.
(5)	–35 Loading.
23–56 Base course—rolling.	–56 Rolling.
(6)	–61 Spreading materials.
23–62 Base course—spreading sand and chips.	–62 Spreading screenings, sand, and chips.
(7)	–63 Sprinkling.
27–36 Top course—loading and hauling.	27 Top course:
	–31 Hauling.
(8)	–32 Heating bituminous materials.
27–34 Top course—laying.	–35 Loading.
	–56 Rolling.
(9)	–60 Spreading bitumen.
27–60 Top course—spreading bitumen.	–61 Spreading materials.
	–62 Spreading screenings, sands, and chips.
(10)	
27–24 Top course—finishing.	23–06 Cleaning base.

The timekeeper had only ten code numbers for general use, but where detailed costs were desired in order to determine relative efficiency and to eliminate wasteful methods 28 code numbers were used.

Detail of Cost Accounts and Necessary Codes.—The detail in which costs are recorded must be left to the judgment of the

supervisor or engineer in charge of the work. Unnecessary refinements are not desirable, as they only increase the work of those who used the data. On the other hand, divisions that are too general and inclusive will prevent the study of results for the purpose of promoting efficiency. The use or final disposition of the data is the factor which should determine the necessary details.

For example, let it be assumed that a county engineer or superintendent desires costs on a brick road for the purpose of making reports on expenditures to the board of highway supervisors. In this case summary costs of completed parts probably would meet the requirements. The divisions would logically be the main divisions of the road and the costs would be collected by these divisions. This would provide the simplest division and consequently the simplest code, which for the case assumed would be as follows:

Cost Divisions

	Code
Right of way	09
Grade and roadside (or grading)	19
Roadway (or surfacing)	29
Ditches and drains	39
Bridges and culverts	49
Supplementary parts	59
Engineering and supervision	69
Administration	99

The first and the last two of these divisions would be compiled from office data so that the cost keeper would be concerned with only five divisions of field data.

The next advanced step that would be desirable in many cases would be the cost of major operations divided by road parts. This would give information suitable for the comparison of results with work of a like character or with unit prices or estimates.

Cost Divisions

Road part	Operation	Code
Right of way:		
Plans and surveys	General	01–26
Real estate		02–
Miscellaneous		09–
Grade and roadside:		
Miscellaneous	Clearing and grubbing	19–08
Miscellaneous	Excavation, common	19–17

Roadway:		
Subgrade	Shaping	20–59
Base course	Laying	23–34
Top course	Laying	27–34
Ditches and drains:		
Paved gutter	Excavating, common	31–17
Paved gutter	Laying	31–34
Tile drains	Laying	33–34
Catch basins	General	33–26
Bridges and culverts:		
Foundations	Excavating, common	40–17
Foundations	Piling driving	40–45
Foundations	General	40–26
Abutments	General	41–26
Superstructures	General	43–26
Miscellaneous		49–
Supplementary parts:		
Signs and sign posts	General	50–26
Guard rails	General	52–26
Curbs	General	53–26
Miscellaneous		59–
Engineering and supervision:		
Supervisory engineering	General	67–26
Inspection	General	68–26
Miscellaneous		69–
Administration:		
Engineering, departmental		97–
Miscellaneous		99–

For the purpose of obtaining costs in more detail than is given in the foregoing, both the class and operation codes are susceptible of further divisions. In the following, divisions are made of the example chosen which are as complete as will generally be practical to use for highway cost keeping except in those cases where efficiency studies are desired.

Cost Divisions

Road part	Operation	Code
Right of way:		
Preliminaries		00–
Right-of-way surveys	General	01–26
Right-of-way plans	General	02–26
Real estate		03–
Damages		04–
Miscellaneous		09–

Grade and roadside:

Cuts and embankments	Excavating, common	10–17
Cuts and embankments	Excavating, borrow	10–16
Cuts and embankments	Drilling	10–14
Cuts and embankments	Blasting	10–03
Cuts and embankments	Loading	10–35
Cuts and embankments	Hauling	10–31
Cuts and embankments	Wasting materials	10–69
Cuts and embankments	Rolling	10–56
Shoulders	Rolling	11–56
Shoulders	Shaping	11–59
Berms and slopes	Trimming	12–66
Berms and slopes	Planting	12–48
Miscellaneous	Clearing	19–07
Miscellaneous	Grubbing	19–28
Miscellaneous	Blasting	19–03

Roadway:

Subgrade	Shaping	20–59
Subgrade	Sprinkling	20–63
Subgrade	Rolling	20–56
Base course	Loading and hauling	22–36
Base course	Forming	22–25
Base course	Mixing	22–38
Base course	Placing	22–46
Base course	Shaping	22–59
Cushion course	General	26–26
Top course	Loading and hauling	27–36
Top course	Laying (brick)	27–34
Top course	Rolling (brick)	27–56
Top course	Grouting	27–27
Top course	Curing concrete	27–11
Miscellaneous	Cleaning	29–06

Ditches and drains:

Ditches and gutters	Excavating, common	30–17
Ditches and gutters paved	Forming	31–25
Ditches and gutters paved	Loading and hauling	31–36
Ditches and gutters paved	Mixing and placing	31–39
Ditches and gutters paved	Finishing	31–24
Ditches and gutters paved	Curing concrete	31–11
Tile drains	Excavating, common	33–17
Tile drains	Laying	33–34
Tile drains	Loading and hauling	33–36
Tile drains	Tamping	33–65
Tile drains	Back filling	33–01
Catch basins	Excavating, common	34–17
Catch basins	Loading and hauling	34–36
Catch basins	Laying (brick)	34–34

Bridges and culverts:

Foundations	Cofferdaming	40–09
Foundations	Cribbing	40–10
Foundations	Excavating, common	40–17
Foundations	Excavating, wet	40–21
Foundations	Forming	40–25
Foundations	Loading and hauling	40–
Foundations	Pumping	40–51
Foundations	Pile driving	40–45
Foundations	Mixing and placing (concrete)	40–39
Foundations	Back filling	41–01
Abutments	Loading and hauling	41–36
Abutments	Laying (masonry)	41–34
Abutments	Pumping	41–51
Abutments	Quarrying (masonry)	41–52
Piers and bents	(Same operations as abutments)	42–
Superstructures	Blacksmithing	43–02
Superstructures	Building false work	43–05
Superstructures	Curing concrete	43–11
Superstructures	Finishing	43–24
Superstructures	Forming	43–25
Superstructures	Loading and hauling	43–36
Superstructures	Mixing and placing (concrete)	43–39
Superstructures	Placing steel	43–47
Box culverts	Excavating, common	44–17
Box culverts	Loading and hauling	44–36
Box culverts	Forming	44–25
Box culverts	Mixing and placing	44–39
Box culverts	Curing concrete	44–11
Pipe culverts	Back filling	45–01
Pipe culverts	Excavating, common	45–17
Pipe culverts	Forming (headwalls)	45–25
Pipe culverts	Laying (pipe)	45–34
Pipe culverts	Loading and hauling	45–36
Pipe culverts	Mixing and placing	45–39
Miscellaneous	Cleaning	49–06

Supplementary parts:

Signs and signposts	Building	50–04
Signs and signposts	Loading and hauling	50–36
Signs and signposts	Painting	50–43
Monuments	General	51–26
Guardrails	Building	52–04
Guardrails	Loading and hauling	52–36
Guardrails	Painting	52–43
Curbs	Back filling	53–01
Curbs	Curing concrete	53–11
Curbs	Excavating, common	53–17
Curbs	Finishing	53–24

Curbs	Forming	53–25
Curbs	Mixing and placing	53–39
Riprap and revetments	Loading and hauling	55–46
Riprap and revetments	Placing matirials	55–46
Roadside treatment	Clearing	56–07
Roadside treatment	Loading and hauling	56–36
Roadside treatment	Planting	56–48
Roadside treatment	Painting	56–43
Engineering and supervision:		
Location and relocation surveys	General	60–26
Surveys for operations	General	61–26
Plans	General	62–26
Specifications and contracts	General	63–26
Estimates	General	64–26
Expense of awards	General	65–26
Office expenses engineering	General	66–26
Supervisory engineering	General	67–26
Inspection	General	68–26
Miscellaneous		69–
Plant and equipment:		
Quarries, pits, etc.	General	71–26
Camp buildings and shelters	General	76–26
Storage and transportation	General	77–26
Miscellaneous	Assembling	79–00
Miscellaneous		79–
Administration:		
Engineering		97–
Miscellaneous		99–

Recording Forms.—Standard forms, to record the daily expenditures of labor, materials, and plant service, should be prepared for the use of the timekeepers or foremen responsible for reports. The use of the nondescript forms or blank books should not be permitted, as such practice will result in unreliable data, often estimated at the end of the day's work, or a jumble of meaningless figures. Forms to be used for recording field data should be reduced, if possible, to pocket size for the sake of convenience. Two such forms are suggested in this bulletin, the sheets being 4¾ in. wide by 10½ in. long. It is not expected that these forms will meet all the requirements for every system, but it is believed that they are correct in principle, and with slight modifications will be found applicable for any organization doing highway work.

The forms designed and suggested herein are based upon and developed from the great number of various forms now in use in

highway work throughout the United States and Canada. The same form is used for labor and equipment operations, but an additional form is necessary for materials, as it would be awkward to make out individual sheets for each kind of material. The daily summary of costs, and the periodic and total summary cost sheets are included, to show the final disposition and use of the data collected on the daily record forms. The final summaries also will fulfill the purpose of a final record of the cost of any job, and can be published for the purpose of substantiating and justifying the amounts expended.

Additional forms are necessary to record progress and character of the work by the supervising engineer, and the methods and amounts of payments made upon the work.

The cost-recording forms are outlined and used as follows:

Form No. 2 (Fig. 37) provided for 40 entries of men or equipment or both and their use on six classifications. The amount for each individual item can be given both in money and in total hours.

This form shows that on Aug. 29, 1917, the foreman F. Smittie employed a gang of laborers numbered from 1 to 21; engineer, No. 4; rollers, No. 1, and No. 2; team, No. 2; guards Nos. 1 and 2; and waterboy, No. 2, on reconstruction work on the B. and W. Road, section 4.

These codes show they were employed as follows:

11–59 Grade and roadside, shoulders, shaping.
23–06 Roadway, base course, cleaning.
23–56 Roadway, base course, rolling.
23–61 Roadway, base course, spreading.
27–34 Roadway, top course, laying.
27–56 Roadway, top course, rolling.

Notes on the sheet show that four laborers were transferred to foreman Rosetta at 9 A.M. and a large part of the crew between 4 and 4.30 P.M.

The daily record of foreman Rosetta's crew (Fig. 38) shows on the same road a crew of 33 laborers, a water boy, roller, and engineer on classsifications—

19–17 Grade and roadside, miscellaneous, excavating, common.
22–56 Roadway, sub-base course, rolling.
22–61 Roadway, sub-base course, spreading.
23–61 Roadway, base course, spreading.

DAILY TIME AND COST RECORD

ROAD B&W SECTION 4 8/29/17 DATE

LOCATION On Road ~~G. M.~~ R.

LABOR OR EQUIPMENT	TIME ON	TIME OFF	HRS.	RATE	TOTAL AMOUNT	CODE 11-59 HRS.	CODE 11-59 AMT.	CODE 23-06 HRS.	CODE 23-06 AMT.	CODE 27-34 HRS.	CODE 27-34 AMT.
F. Smittie	7.00	5.00			4 40						
Laborer 1	"	4.30	8½	.375	3 19					卌III½	3 19
2	"	"	"	"	3 19					卌III½	3 19
3	"	"	"	"	3 19					卌III½	3 19
4	"	"	"	"	3 19					卌III½	3 19
5	"	"	"	"	3 19					卌III½	3 19
6	"	"	"	"	3 19					卌III½	3 19
7	"	"	"	"	3 19					卌III½	3 19
Sent to Rosetta 8	"	"	"	"	3 19					卌III½	3 19
9	"	"	"	"	3 19					卌III½	3 19
10	"	"	"	"	3 19					卌III½	3 19
11	"	"	"	"	3 19					卌III½	3 19
12	"	4.00	8	"	3 00	II	75	I	37	卌	1 88
13	"	"	"	"	3 00					卌III	3 00
14	"	"	"	"	3 00					卌III	3 00
15	"	"	"	"	3 00	卌	1 88	I	37	II	75
16	"	5.00	9	"	3 37					卌IIII	3 37
17	"	"	"	"	3 37	卌IIII	3 37				
			TOTAL				6 00		74		47 09
						23-56		23-61		27-56	
Sent to Rosetta 18	"	9.00	2	.375	75			II	75		
19	"	"	"	"	75			II	75		
20	"	"	"	"	75			II	75		
21	"	"	"	"	75			II	75		
Engineer 4	"	5.00	8	.50	4 00	III	1 50			卌	2 50
Roller 1	"	"			5 00	III	5 00				
" 2	"	"			5 00					卌	5 00
Team 2	10.00	12.00	2		1 50	I	75			I	75
Guard 1	7.00	5.00	9		2 80						
" 2	"	"	9		2 80						
Waterboy 2	"	"	9		88	Half time to Rosetta					
			TOTAL				7 25		3 00		8 25
	Mixing Plant closed down at 4 P.M.										
			Gang sent to Rosetta								
			TOTAL		83 21						

FIG. 37.

DAILY TIME AND COST RECORD

ROAD B.&W. SECTION 4 8/29/17 DATE

LOCATION On Road ~~C.M.~~R.

LABOR OR EQUIPMENT	TIME ON	TIME OFF	HRS	RATE	TOTAL AMOUNT	CODE 19-17 HRS.	CODE 19-17 AMT.	CODE 22-61 HRS.	CODE 22-61 AMT.	CODE 23-61 HRS.	CODE 23-61 AMT.
F. Rosetta	7.00	5.00			3 75						
Laborer 22	"	"	9	.375	3 37	卌 |	2 25	|||	1 12		
23	"	"	"	"	3 37	卌 |	2 25	|||	1 12		
24	"	"	"	"	3 37	卌 ||	2 62	||	75		
25	"	"	"	"	3 37	卌 ||	2 62	||	75		
26	"	"	"	"	3 37	卌 ||||	3 37				
27	"	"	"	"	3 37	卌 ||||	3 37				
28	"	"	"	"	3 37	卌 ||||	3 37				
29	"	"	"	"	3 37	卌 ||||	3 37				
30	"	"	"	"	3 37	卌 ||||	3 37				
31	"	"	"	"	3 37	卌 ||||	3 37				
From Smittie's Gang 18	9.00	"	7	"	2 62					卌 ||	2 62
19	"	"	"	"	2 62					卌 ||	2 62
20	"	"	"	"	2 62	|||	1 12	|||	1 12	|	37
21	"	"	"	"	2 62	|||	1 12	|||	1 12	|	37
From Carter's Gang 32	10.00	"	6	"	2 25	卌 |	2 25	TOTAL	5 98		
33	"	"	"	"	2 25	卌 |	2 25				
34	"	"	"	"	2 25	卌 |	2 25				
35	2.00	"	3	"	1 12	|||	1 12				
From Smittie's Gang 11	4.00	"	1	"	37	|	37				
12	"	"	"	"	37	|	37				
13	"	"	"	"	37	|	37				
14	"	"	"	"	37	|	37				
15	"	"	"	"	37	|	37				
1	4.30	"	½	"	18	½	18				
2	"	"	"	"	18	½	18				
3	"	"	"	"	18	½	18				
4	"	"	"	"	18	½	18				
5	"	"	"	"	18	½	18				
6	"	"	"	"	18	½	18				
7	"	"	"	"	18	½	18				
8	"	"	"	"	18	½	18				
9	"	"	"	"	18	½	18				
10	"	"	"	"	18	½	18	22-56			
Engineer 2			6	.666	4 00	卌	3 33	|	67		
Roller 3			6	.833	5 00	卌	4 17	|	83		
								TOTAL	1 50		
Waterboy 2					87	Half time with Smittie					
			TOTAL		69 32		51 22				5 98

Fig. 38.

DAILY TIME AND COST RECORD

ROAD *Route 2* SECTION *A* *8/24/17* DATE

LOCATION *On Road* C. ~~M.R.~~

LABOR OR EQUIPMENT	TIME ON	TIME OFF	HRS	RATE	TOTAL AMOUNT	CODE 11-59 HRS.	CODE 11-59 AMT.	CODE 20-59 HRS.	CODE 20-59 AMT.	CODE HRS.	CODE AMT.
A8	7.00	6.00	10	.625	6 25						
Laborer 174	"	8.30	1½	.375	55	1½	55	Fired			
187	9.30	2.30	4	"	1 50	IIII	1 50	Fired			
188	"	"	4	"	1 50	IIII	1 50	Sent to Tool House			
189	"	6.00	7½	"	2 80			卌 II½	2 80		
197	"	2.30	4	"	1 50	IIII	1 50	Sent to Tool House			
199	"	6.00	7½	"	2 80			卌 II½	2 80		
408	7.00	"	10	"	3 75			卌 卌	3 75		
414	8.00	"	9	"	3 37	卌 IIII	3 37				
431	7.00	"	10	"	3 75			卌 卌	3 75		
432	"	"	10	"	3 75			卌 卌	3 75		
437	11.00	"	6	"	2 25	卌 I	2 25				
439	7.00	"	10	"	3 75			卌 卌	3 75		
440	"	"	10	"	3 75			卌 卌	3 75		
448	"	"	10	"	3 75	卌 卌	3 75				
454	"	"	10	"	3 75	卌 卌	3 75				
465	"	"	10	"	3 75	卌 I	2 25	IIII	1 50		
469	"	"	10	"	3 75	卌 卌	3 75				
470	"	"	10	"	3 75	卌	1 87	卌	1 88		
475	"	"	10	"	3 75	卌 卌	3 75				
477	"	8.30	1½	"	55	1½	55	Sent to Steam Shovel 2			
478	"	6.00	10	"	3 75			卌 卌	3 75		
479	"	"	10	"	3 75	卌 卌	3 75				
484	"	8.30	1½	"	55	1½	55				
485	"	"	1½	"	55	1½	55	Sent to Steam			
486	"	"	1½	"	55	1½	55	Shovel 2			
487	"	9.30	2½	"	93	1½	93	Fired			
495	"	8.30	1½	"	55	1½	55	Sent to Steam Shovel 2			
500	"	4.00	8	"	3 00			卌 III	3 00		
501	"	8.30	1½	"	55	1½	55	Sent to Steam Shovel 2			
506	"	6.00	10	"	3 75	Carrying Water					
532	"	"	10	"	3 75	卌 卌	3 75				
568	11.00	"	6	"	2 25	卌 I	2 25				
599	"	12.00	1	"	37	1	37	Sent to Tool House			
195	"	2.30	1½	"	55			1½	55	Sent to Tool House	
Team 21	7.00	12.00	5	.80	4 00			卌	4 00		
" 22	"	"	5	"	4 00			卌	4 00		
Grader	"	"	5	.50	2 50			卌	2 50		
TOTAL					99 67		44 14		45 63		

FIG. 39.

Laborers were received three times during the day from foreman Smittie and once from foreman Carter.

In Fig. 39 is shown the work of a large crew, but on only two operations. A number of changes in the crew will be observed. Only 15 men out of a total of 36 employed worked the full day with foreman A8.

Material and Supplies.—The form for materials and supplies (Fig. 40) is the same size as that for labor and equipment and may be carried by the timekeeper or foreman in the same book or binder with the other form. The material form is for 1 day only and 12 different materials may be recorded on a single sheet. The sheet shows distribution as follows:

ROAD Ashland-Lexington DAILY RECORD OF MATERIALS AND SUPPLIES B. Messing.. FOREMAN
SECTION Cemetery Bridge DATE Sept. 19, 1910 C ~~M.R.~~

KIND	UNIT	RATE	CODES, UNITS, AND AMOUNTS											
			43-39		41-39		43-25		43-47					
			UNITS	AMOUNT	UNITS	AMOUNT	UNITS	AMOUNT	UNITS	AMOUNT	UNITS	AMOUNT	UNITS	AMOUNT
Cement	Bag	.47	150	70 50	10	4 70								
Lumber	M	30.00					1.2	36 00						
Nails	lb.	.035					20	70						
Wire	lb.	.035					10	35	8	28				
Gasoline	Gal.	.20	5	1 00	1	20								
Sand	C.Y.	.60	22	13 20	2	1 20								
Steel	lb.	.03							7800	234 00				
Oil				10										
TOTAL AMOUNTS				84 80		6 10		37 05		234 28				
WHERE USED			West Span		East Abutment		West Span		3 West Spans					

FIG. 40.

FOR OPERATION 43–39, MIXING AND PLACING SUPERSTRUCTURE

150 bags cement, at $0.47	$70.50
5 gallons gasoline, at $0.20	1.00
22 cubic yards sand, at $0.60	13.20
Oil	.10
Total for operation (used on west span)	84.80

FOR OPERATION 41–39, MIXING AND PLACING ABUTMENT

10 bags cement, at $0.47	$4.70
1 gallon gasoline, at $0.20	.20
2 cubic yards sand, at $0.60	1.20
Total for operation (used on east abutment)	6.10

For operation 43–25, Forming Superstructure

1,200 ft B. M lumber, at $0.03	$36.00
20 pounds nails, at $0.035	.70
10 pounds wire, at $0.035	.35
Total for operation (used on west span)	37.05

For Operation 43–47, Superstructure, Placing Steel

8 pounds wire, at $0.035	$0.28
7,800 pounds steel, at $0.03	234.00
Total for operation (used on 3 west spans)	234.28

Daily Report of Costs.—When the records of the amount of labor, the service of equipment, and the expenditures of materials have been completed the data for arriving at unit costs are at hand. For convenience in bringing together these three elements of cost, a form has been drawn up called the "Daily report of costs." This is not for field use and is 8½ in. wide and 13½ in. long. The unit costs are arrived at by setting down against the code number all labor equipment and material charges in detail. These are added together and the sum is divided by the units of work completed as estimated by the foreman. The units completed are checked against the engineer's monthly estimate and should not show a very great discrepancy, say not over 5% at the outside.

Sample labor and equipment and materials forms for work of constructing a field stone base course of a road and the daily report of costs form filled out from these are shown on pages 249, 250 and 251.

These three forms compose the entire set needed to record the field operations and compute unit costs of such operations.

Immediate Use of Cost Data.—When the daily reports of costs reach the official responsible for the work he can readily prepare a graph (Fig. 41) showing both the estimated unit cost and the actual daily unit cost in convenient form. Any wide divergence between the estimated and actual costs is apparent at once and can be investigated. The horizontal axis of the graph in this case is divided to show the days of the month. The vertical axis is divided to show the unit cost of the work. Some such chart will show effect of conditions upon the work.

Final Disposition of Cost Data.—It has been pointed out that the objects of a cost-keeping system are two. First, to show the efficiency of performance and facilitate the reduction of costs, and, second, to supply data which may be used for the intelligent estimating of future improvements and to furnish materials for published reports.

Highway work obviously is a public improvement paid for entirely from funds derived from the public revenue. Ultimately, then, the taxpayer pays for all of this improvement and is entitled to a full and detailed account of how this money was expended. Again, public records of this kind are all that remain to be used for the comparing of the efficiency of one administration with that of another. It would appear, therefore, to be a step in the direc-

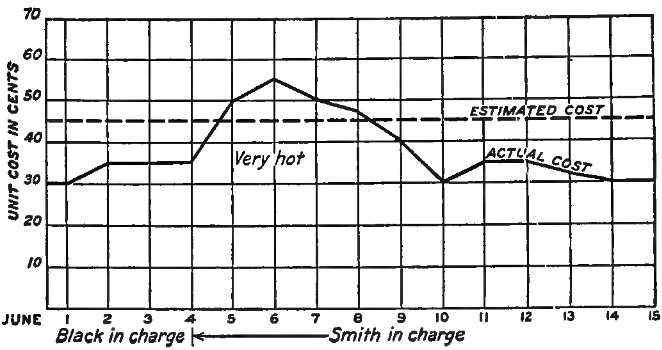


FIG. 41.—Graph showing estimated and actual costs.

tion of good judgment for all those in charge of public improvements to adopt some simple system of cost keeping such as is outlined herein, which could be used both as an aid to present efficiency and as a complete report of the ability of the officials in charge to get the most for the public funds.

For the purpose of presenting in concise form the costs and also to show the progress being made during the period of construction the form shown on page 252, "Report of Progress and Cost," is suggested. The costs which comprise this report may be compiled from daily reports. Such compilation may be made from day to day on a form similar to the one shown on page 253. Where the cost data are derived in greater detail than is provided for by this form, the "Cost Compilation Form" may be arranged in several sheets.

DAILY TIME AND COST RECORD

ROAD *Route 2* SECTION *A* *8/25/17* DATE

LOCATION *40+75 to 45+00* C. ~~M.R.~~

LABOR OR EQUIPMENT	TIME ON	TIME OFF	HRS	RATE	TOTAL AMOUNT	CODE 23-34 HRS	CODE 23-34 AMT.	CODE 20-59 HRS.	CODE 20-59 AMT.	CODE 23-12 HRS.	CODE 23-12 AMT.
F. Waugh	7.00	6.00	10	.75	7 50						
Laborer 592	"	"	"	.412	4 12	𝍸𝍸	4 12				
601	"	"	"	"	4 12	𝍸/	2 47			////	1 65
610	"	"	"	"	4 12	𝍸	2 06			𝍸	2 06
590	"	"	"	"	4 12	𝍸	2 06			𝍸	2 06
589	"	"	"	"	4 12	///	1 24	///	1 24	////	1 64
533	"	"	"	"	4 12	𝍸	2 06			𝍸	2 06
546	9.00	"	8	"	3 30	𝍸	2 06	///	1 24		
481	10.00	"	7	"	2 88	𝍸/	2 47	/	41		
474	7.00	"	10	"	4 12	𝍸𝍸	4 12				
473	"	"	"	"	4 12	𝍸///	3 30			//	82
467	"	"	"	"	4 12	𝍸///	3 30			//	82
466	"	"	"	"	4 12	𝍸///	3 30	//	82		
422	10.00	"	7	"	2 88	𝍸//	2 88				
					TOTAL	86	35 44				
						11-59					
420	7.00	6.00	10	.412	4 12	𝍸/	2 47	///	1 24	/	41
425	"	"	"	"	4 12	𝍸///	3 30	//	82		
					TOTAL	14	5 77	14	5 77	28	11 52
						23-56		23-31			
Team 9	7.00	6.00	10	.80	8 00			𝍸𝍸	8 00		
12	"	"	"	"	8 00			𝍸𝍸	8 00		
15	"	"	"	"	8 00			𝍸𝍸	8 00		
16	"	"	"	"	8 00			𝍸𝍸	8 00		
17	"	"	"	"	8 00			𝍸𝍸	8 00		
18	"	"	"	"	8 00			𝍸𝍸	8 00		
23	"	"	"	"	8 00			𝍸𝍸	8 00		
Waterboy 115	"	"	"	.275	2 75						
Engineer 169	"	"	"	.625	6 25	𝍸𝍸	6 25				
Roller 13		Day			8 00	Day	8 00				
Team 5	8.00	6.00	9	.80	7 20			𝍸////	7 20		
19	"	"	"	"	7 20			𝍸////	7 20		
21	"	"	"	"	7 20			𝍸////	7 20		
25	"	"	"	"	7 20			𝍸////	7 20		
30	"	"	"	"	7 20			𝍸////	7 20		
3	2.00	3.00	1	"	80	/	80				
					TOTAL	11	15 05	115	92 00		
				TOTAL	175 80						

FIG. 42.

The "Final Cost Summary" shown on page 254 is for the purpose of bringing together all expenditures involved and all units of work done, and to show unit costs, total cost of parts, per cent of cost by parts, and total cost of the entire improvement.

The daily time and cost record of foreman Waugh's crew (Fig. 42) shows:

86 hr. labor on code 23–34 (laying base course)	$35.44
14 hr. labor on code 11–59 (shaping shoulders	5.77
14 hr. labor on code 20–59 (shaping sub-grade)	5.77
28 hr. labor on code 23–12 (crushing base course)	11.52
10 hr. labor, 1 hr. team hire on code 23–56 (rolling base course)	15.05
115 hr. team hire on code 23–31 (hauling base course)	92.00

ROAD *Route 2* — DAILY RECORD OF MATERIALS AND SUPPLIES — *F. Waugh* FOREMAN
SECTION *A* — DATE *8/25/17* — C. ~~M. R.~~

KIND	UNIT	RATE	CODES, UNITS, AND AMOUNTS											
			23-34		*23-56*									
			UNITS	AMOUNT	UNITS	AMOUNT	UNITS	AMOUNT	UNITS	AMOUNT	UNITS	AMOUNT	UNITS	AMOUNT
Fld. Stone	*C.Y.*	*.25*	*87*	*21 75*										
Coal	*Ton*	*4.00*			*.25*	*1 00*								
TOTAL AMOUNTS				*21 75*		*1 00*								
WHERE USED.			*43+75 to 41+50*		*45+00 to 41+00*									

FIG. 43.

The daily record of materials and supplies (Fig. 43) shows:

Expenditures for 87 cu. yd. fired stone on code 23–34 (laying base course)	$21.75
One-quarter ton coal on code 23–56 (rolling base course)	1.00

These data are combined and arranged on the daily report of costs form (Fig. 44) so as to make possible the ready determination of unit costs. In this case no indirect labor cost is charged to equipment. Teams were used only for hauling and were required to make a certain number of trips per day.

The amount of work done was reported to the superintendent by the engineer in charge of this division of the work.

DAILY REPORT OF COSTS

C.M.R.

ROAD *Route 2* ...... SECTION *A* ...... WEATHER *Clear-Warm* FOREMAN *F. Waugh* ...... DATE *8-25-17*

CODE NUMBERS	LABOR				EQUIPMENT				MATERIALS & SUPPLIES					LABOR EQUIPMENT SUPPLIES MATERIALS	UNITS OF WORK COMPLETED		UNIT COST	LOCATION
	KIND	HOURS	RATE	AMOUNT	KIND	HOURS	RATE	AMOUNT	KIND	UNIT	NUMBER	RATE	AMOUNT		NUMBER	UNIT		
11-59	Labor	14	412	5 77														
	Indirect			94										6 71	300	Per foot	022	43+75 to 40+70
																of road	013	sq. yd. of roadway
20-59	Labor	14	412	5 77														43+75 to 40+75
	Indirect			94										6 71	533.3	sq. yds.	013	16 ft. wide
23-12	Labor	28	412	11 52														43+75 to 41+48
	Indirect			1 89										13 41	404	sq. yds	033	16 ft. wide
23-34	Labor	86	412	35 44					Fld Stone	C.Y.	87	25	21 75					43+75 to 41+48
	Indirect			5 80										62 99	404	sq. yds	156	16 ft. wide
23-31					Teams	115	80	92 00						92 00	404	sq. yds	228	43+75 to 41+48
23-56	Engineer	10	625	6 25	Team	1	80	80	Coal	Ton	.25	4 00	1 00					45+00 to 41+00
	Indirect			67	Roller	day		8 00						16 72	711	sq. yds	024	16 ft. wide
Totals		152		74 99				100 80					22 75	198 54	Per sq. yd. siding		467	
Indirect	Foreman	10	75	7 50														
	Wt. Boy	10	275	2 75	Basis for distribution													
					Indirect labor expenses													
	Labor	152	0674	10 25	on direct labor costs													

FIG. 44.

REPORT OF PROGRESS AND COST

Road No. 144—Sections A | Construction | Period from Mar. 1 to 15, 1917

Code Nos.	Classification	Unit	For this period: Units completed	For this period: Total cost	For this period: Unit cost	Summary to date: Units completed	Summary to date: Total cost	Summary to date: Unit cost	Completed, per cent
	Right of way:								
01–26	Plans and surveys, general	....	.....	....	......	......	$ 400.00	....	100
02	Real estate	Acre	10	$ 500.00	$50.00	25	1,500.00	$60.00	80
09	Miscellaneous	....	.....	600.00	......	......	1,200.00	......	85
	Grade and roadside:								
19–08	Clearing and grubbing	Acre	4	160.00	40.00	19	950.00	50.00	57
19–17	Miscellaneous, excavation, common	Cubic yard	500	150.00	0.30	2,000	500.00	0.25	50
	Roadway:								
20–59	Subgrade, shaping	Square yard	1,200	36.00	0.03	16,000	64.00	0.04	10
23–34	Base course, laying	Square yard	1,000	900.00	0.90	16,000	14,400.00	0.90	10
27–34	Top course, laying	Square yard	1,600	960.00	0.60	1,600	960.00	0.40	1
	Ditches and drains:								
31–17	Paved gutter, excavation, common	Linear foot	400	8.00	0.02	1,000	30.00	0.03	6
31–34	Paved gutter, laying	Linear foot	200	80.00	0.40	800	320.00	0.40	5
33–34	Tile drains, laying	Linear foot	50	15.00	0.30	50	15.00	0.30	2
33–26	Catch basins, general	....	2	40.00	20.00	3	60.00	22.00	25
	Bridges and culverts:								
40–17	Foundations, excavation, common	Cubic yard	2,000	1,600.00	0.80	3,000	2,400.00	0.80	80
40–45	Foundations, piling, driving	Linear foot	1,200	480.00	0.40	2,000	1,000.00	0.50	45
40–26	Foundations, general	Cubic yards	125	1,457.50	11.50	125	1,457.50	11.50	80
41–26	Abutments, general	Cubic yards	400	3,600.00	9.00	400	3,600.00	9.00	60
43–26	Superstructures, general	Cubic yards	120	1,920.00	16.00	120	1,920.00	16.00	..
49–26	Bridges and corrugated pipe culverts, general	Linear foot	150	300.00	2.00	150	300.00	2.00	40
	Supplementary parts:								
50–26	Signs and sign posts, general	....	75	150.00	2.00	100	210.00	2.10	50
52–26	Guardrails, general	Linear foot	100	100.00	1.00	300	300.00	1.00	40
53–26	Curbs, general	Linear foot	1,000	200.00	0.20	2,000	450.00	0.22½	20
59–26	Monuments, general	....	10	30.00	3.00	10	30.00	3.00	40
	Engineering and supervision:								
67–26	Supervisory engineering, general	....	.....	60.00	......	......	300.00	....	..
68–26	Inspection, general	....	.....	100.00	......	......	500.00	....	..
69–	Miscellaneous	....	.....	10.00	......	......	15.00	....	..
	Total expenditures	....	.....	$13,456.00	......	......	$32,887.50	....	..

Cost Compilation

Road No. ....
Sections ....
Work begun ....
Completed ....

.... Superintendent

Construction
Maintenance
Reconstruction

Date		Source of item	Right of way			Grade and road-side		Road-way			Ditches and drains				Bridges and culverts						Supplemen-tary parts				Engineer-ing and super-vision			Admin-istra-tion		Totals
Mo.	Day		01–26	02–	09–	19–08	19–17	20–59	23–34	27–34	31–17	31–34	33–34	33–26	40–17	40–45	40–26	41–26	43–26	49–	50–26	52–26	53–26	59–26	67–26	68–26	69–	97–	99–	

This form will be found very useful for the purpose of compiling costs. The data on the "Daily Reports of Costs" may be recorded each day and at any period the total costs by items may be obtained readily by adding the cost items already collected.

FINAL COST SUMMARY

Road..............
Sections.............
....
Sup't.

Cost of Construction...........
Date of Acceptance............

[Items including cost of labor, materials, supplies, and rental of equipment]

Road part	Operation	Code	Units	Unit cost	Cost	Total cost	Percentage of whole cost
Right of way:							Per cent
Plans and surveys	General	01–26	Acres				
Real estate		02–	Acres				
Miscellaneous		09–	Acres				
Grade and roadside:							
Miscellaneous	Clearing and grubbing	19–08	Acres				
Miscellaneous	Excavation, common	19–17	Cubic yard				
Roadway:							
Subgrade	Shaping	20–59	Square yard				
Base course	Laying	23–34	Square yard				
Top course	Laying	27–34	Square yard				
Ditches and drains:							
Paved gutter	Excavation, common	31–17	Linear foot				
Paved gutter	Laying	31–34	Linear foot				
Tile drains	Laying	33–34	Linear foot				
Catch basins	General	33–26	Only				
Bridges and culverts:							
Foundations	Excavation, common	40–17	Cubic yard				
Foundations	Piling, driving	40–45	Linear foot				
Foundations	General	40–26	Cubic yard				
Abutments	General	41–26	Cubic yard				
Superstructures	General	43–26					
Miscellaneous		49–					
Supplementary parts:							
Signs and sign posts	General	50–26	Linear foot				
Guard rails	General	52–26	Linear foot				
Curbs	General	53–26	Linear foot				
Miscellaneous		59					
Engineering and supervision:							
Supervisory engineering	General	67–26					
Inspection	General	68–26					
Miscellaneous		69					
Administration:							
Engineering, departmental		97					
Miscellaneous		99					
Grand total							

Definitions of Road Operation Terms.—In road work it is not uncommon to find that the same operations are designated by different terms in different sections of the country. It has been thought advisable, therefore, to define briefly the processes which should be included by the cost keeper under each operation. Some of these operations will be found to overlap somewhat under certain conditions. This slight overlapping, however, seems preferable to the present ambiguity in the meaning of many of our road terms. Adherence to the following definitions will serve, therefore, to make such cost data as are collected more nearly comparable, regardless of locality. The several operations are defined in terms of the processes which they include.

Assembling.—Shall include all bringing together or collecting of tools and equipment, setting up of machinery, portable shacks, and all other structures where the parts are delivered "knocked down" and require only bolting or riveting ogether.

Back Filling.—Shall include all processes of refilling excavations or filling against the back of abutments, walls, etc.

Blacksmithing.—Shall include all processes of working or shaping metals, except riveting, and shall include also such work in repairing the metal parts of machinery and equipment.

Blasting.—Shall include all methods of rending or loosening of rock, earth, or other material with an explosive.

Building.—Shall include the making, erecting, and establishing of buildings, structures, or parts, except bridges or portable structures delivered cut to fit.

Building False Work.—Shall include the building or erecting of all temporary supports and bracing necessary for the erection of structures.

Cleaning.—Shall include all removal of dirt or débris by any means from the surfaces of roadways or from ditches, drains, culverts, etc , and shall include the sweeping of all road surfaces. It shall be applied also to the operations necessary to remove deleterious matter or coatings from the surfaces of such structures as bridges, buildings, guardrails, etc.

Clearing.—Shall include the freeing of the roadway and roadside of all vegetation or incumbrances.

Clearing and Grubbing.—Shall include in addition to clearing, as defined above, the removal and disposal of stumps.

Cofferdamming.—Shall include only the building of cofferdams.

Cribbing.—Shall include the building of all kinds of timber cribs to retain or sustain earth work.

Curing Concrete.—Shall include the careful protection and slow drying of concrete, to prevent cracking or injury of any kind until the concrete has hardened.

Crushing.—Shall include all reducing of stone or other material to small particles by pounding or squeezing, whether the work be done by machine or hand.

Dragging.—Shall include the smoothing of a roadway surface or the shaping and partial compacting of road courses with a road drag.

Drilling.—Shall include the piercing or boring of any material, as iron or rock, with drills operated by hand or driven by power.

Drilling and Blasting.—Shall include, in addition to the drilling, the loading of the holes with an explosive and the detonation of the explosive charge.

Excavating.—Shall include the grading of the roadway, ditches, and slopes, and also the hollowing out by cutting or digging of all excavations for drainage structures.

Filling Ruts.—This operation needs no explanation.

Filling Washouts.—This operation needs no explanation.

Finishing.—Shall include all other work necessary to complete a road or part of a roadway.

Forming.—Shall include the building of all forms for concrete work and the removal of the same.

General.—Shall include all charges impossible to allocate directly as belonging to any other operation in the table, or as a summary of operations on particular posts when desired.

Grouting.—Shall include all filling out and finishing of any work with a thin watery cement or cement and sand mixture, as the grouting of brick, pavements, etc.

Grubbing.—Shall include the removal of stumps and roots.

Guarding.—Shall include all charges for watchmen, barriers, signs, and warning lights during the period that the road is being constructed or repaired.

Harrowing.—Shall include all methods of breaking up clods of material on the road or mixing with harrows the materials of which the road is to be made. It differs from loosening.

Hauling.—Shall include the transportation of materials or equipment.

Heating.—Shall include all processes of raising the temperatures of materials by the application of heat.

Laying.—Shall include the coating, spreading over, or covering any roadway course or road surface with any material, the placing in definite position of similar individual pieces of prepared material, or the constructing of a roadway course.

Loading.—Shall include the placing of any object or material in a conveyance.

Loading and Hauling.—Shall include a combination of loading and hauling, both of which have been defined.

Loosening.—Shall include the breaking up of a dense, close mass, as an old road surface, into detailed particles with picks, scarifiers, or any other equipment.

Mixing.—Shall include all blending of materials into masses by stirring or turning, such as the mixing of concrete, water, aggregate, etc., but shall not include harrowing.

Mixing and Placing.—Shall include, in addition to mixing, the locating of the mixed material in a desired position.

Moving.—Shall include all operations necessary for shifting or changing the position of any object. Thus it is a general term and may include a number of specific operations.

Operating.—Shall include the continuing in activity of any machinery.

Oiling.—Shall include the spraying or coating of a road surface with liquid bituminous matter.

Painting.—Shall include the covering of any object with a coating of a prepared pigment; also shall include whitewashing.

Patroling.—Shall include the continuous services of patrolmen repairing and maintaining a designated stretch of road.

Pile Driving.—Shall include the placing of piles or sheathing by means of a driving hammer.

Placing.—Shall include the locating in a desired position of any object or material.

Planting.—Shall include the putting or placing of any sod, seed, shrub, or tree for growth.

Plumbing.—Shall include the preparation and placing of pipes, pumps, etc. required to deliver water to the road.

Plowing.—Shall include the loosening of any material by the use of a plow.

Pumping.—Shall include the lifting or driving of any material by pumps.

Quarrying.—Shall include the taking out of stone from an excavation or quarry.

Removing Snow.—Requires no explanation.

Repairing.—Shall include all acts of returning to a sound state any road part where the work done is not extensive enough to be classified as reconstruction.

Riveting.—Shall include the uniting of two or more pieces with rivets and the heading of the rivets.

Rolling.—Shall include all compressing of roadway or surface material with a hand, horse, or power roller.

Scarifying.—Shall include the loosening or stirring up of the surface or the breaking of a bond of the road. This is almost synonymous with loosening.

Screening.—Shall include the removal of all undesirable particles from any material by passing it through or over a screen, or both.

Shaping.—Shall include all processes of bringing road parts as subgrade, shoulders and courses to a regular form of section.

Spreading.—Shall include the scattering or distributing of any materials over a large surface in order to form a coating or layer of uniform depth.

Sprinkling.—Shall include the distribution of water, in a fine coat over a surface.

Stripping.—Shall include all removing or taking off the cover or burden from gravel pits or quarries.

Trimming.—Shall include the cutting off of small quantities of excavation to make the roadway or roadside conform to a regular outline or section.

Washing.—Shall include the removal of any undesirable matter from a material by use of water.

Washing and Screening.—Shall include, in addition to washing, the processes explained under screening.

Wasting Material.—Shall include all depositing on a dump or spoil bank of excavated materials that can not be used in embankment.

Waterproofing.—Shall include all protecting from water of concrete walls, etc., by the use of bituminous or any other material.

Working on Joints.—Shall include all the labor made necessary by the introduction of expansion or contraction joints, natural or artificial, and also the openings between regular sets, as the joints in a brick roadway.

Wrecking.—Shall include the tearing down or destroying of any structures.

References.—The authors acknowledge their indebtedness to the following sources of information:

The cost-account systems of the following State highway departments: Arizona, Illinois, Maryland, Oregon, Pennsylvania, and Wisconsin; "Efficient Cost Keeping," by E. St. Elmo Lewis; "Efficiency," by Harrington Emerson; "Cost Data," by H. P. Gillette; "Cost-Keeping and Scientific Management," by H. A. Evans; "Cost Records for Executives as a Means of Plant Control," by B. A. Franklin; "Cost Keeping and Management Engineering," by H. P. Gillette and R. T. Dana; "Cost Accounts," by L. W. Hawkins; "Psychology and Industrial Efficiency," by Hugo Munsterberg; "Cost Accounts," by J. L. Nicholson; "The Principles of Scientific Management," by Frederick W. Taylor; "Cost Accounting," by J. R. Wildman; "Modern Accounting," by H. R. Hatfield; "The Handbook of Municipal Accounting," by the Bureau of Municipal Research; The Cost-Accounting System of the Ontario Highway Department; the Cost-Accounting System used by the Bureau of Public Works of the Philippine Islands; an article on "Cost Accounting," by Capt. Godfrey, and the subsequent discussions on the subject in the Army Engineers' Magazine; "Memoirs of Army Engineers;" and in addition the Study of Cost-Accounting Systems in use in many counties, cities, and towns in the United States, and the chapter on "Cost Finding" in Volume XI of the Alexander Hamilton Institute, and the Transactions of the American Society of Civil Engineers.

CHAPTER VII

BOOKKEEPING FOR SMALL CONTRACTORS

Simplicity Essential.—Most articles and books describe complex bookkeeping systems which are impossible for the average contractor who must depend on a moderate-priced bookkeeper, or even a stenographer with a slight knowledge of bookkeeping. While today most firms in this class are still able to do business with poor records because their small awards are obtained from friendly sources or through "pull" of some kind, competition is day by day making inroads on this field. That these firms are aware of the danger of their position is clearly indicated by the increased number of inquiries received by accountants and engineering cost specialists regarding simple accounting systems. It is with these contractors in mind that this chapter is written.

Let us suppose that the office force of a small contracting firm largely engaged in building work, for which we are about to design a bookkeeping system is made up of two owners, one of whom acts as Manager and the other as Chief Engineer, the former attending to the business end and the latter the construction end, supervising the designing and estimating and acting as superintendent; an estimator who also does whatever drafting there may be; a stenographer who looks after the correspondence, the files and the telephone; a bookkeeper who is responsible for the records; and an office boy.

With such a limited force available for the work, it is clear that simplicity must be the keynote, even if the results obtained are not theoretically accurate at some points.

Partnership agreements often contain a clause which states that each partner is to receive a salary, naming the amounts. Although this makes no difference in the total amount received from the business by each partner, it aids in making up the cost records; and we will assume that such an agreement has been entered into by the partners of the business under consideration.

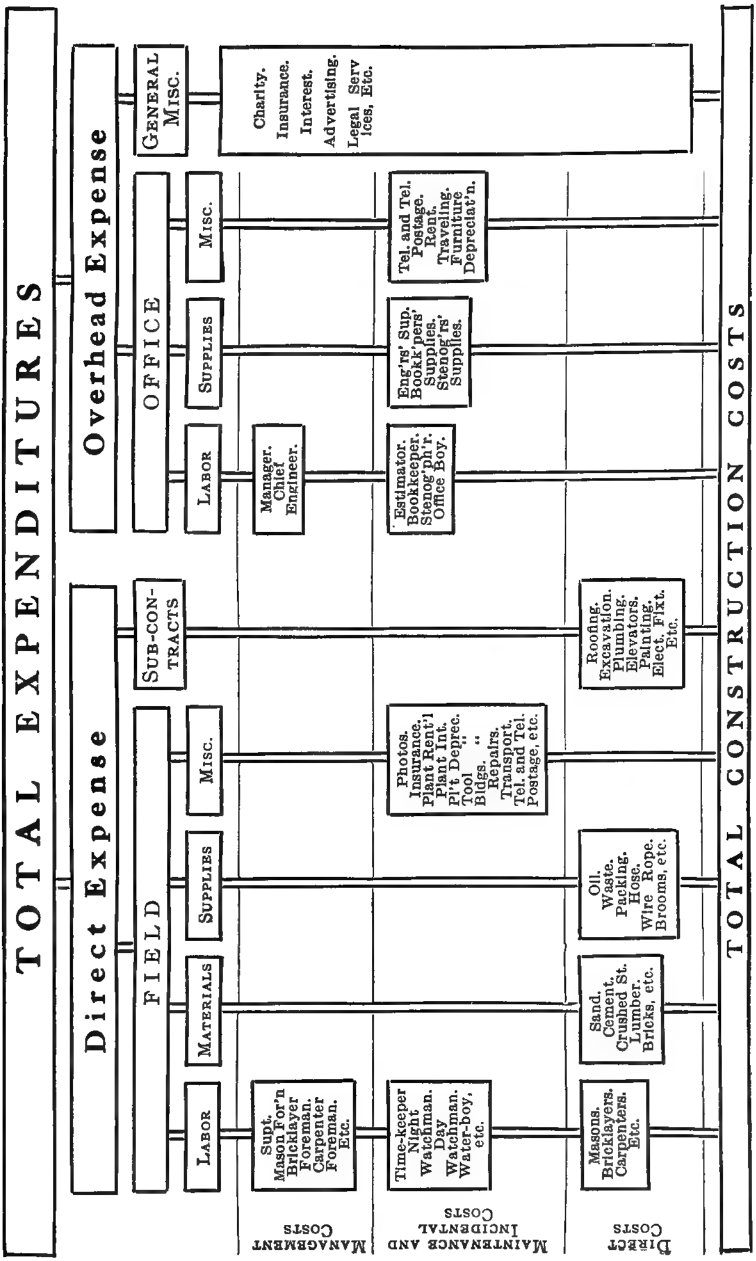

TOTAL EXPENDITURES
Direct Expense
Overhead Expense
FIELD
SUB-CONTRACTS
OFFICE
GENERAL MISC.
LABOR
MATERIALS
SUPPLIES
MISC.
LABOR
SUPPLIES
MISC.
Charity. Insurance. Interest. Advertising. Legal Services, Etc.
Supt. Mason For'n Bricklayer Foreman. Carpenter Foreman. Etc.
Time-keeper Night Watchman. Day Watchman. Water-boy, etc.
Masons. Bricklayers. Carpenters. Etc.
Sand. Cement. Crushed St. Lumber. Bricks, etc.
Oil. Waste. Packing. Hose. Wire Rope. Brooms, etc.
Photos. Insurance. Plant Rent'l Plant Int. Pl't Deprec. Tool " Bldgs. " Repairs. Transport. Tel. and Tel. Postage, etc.
Roofing. Excavation. Plumbing. Elevators. Painting. Elect. Fixt. Etc.
Manager. Chief Engineer.
Estimator. Bookkeeper. Stenog'ph'r. Office Boy.
Eng'rs' Sup. Bookk'pers' Supplies. Stenog'rs' Supplies.
Tel. and Tel. Postage. Rent. Traveling. Furniture Depreciat'n.
MANAGEMENT COSTS
MAINTENANCE AND INCIDENTAL COSTS
DIRECT COSTS
TOTAL CONSTRUCTION COSTS

Chart I.

For the sake of clearness we will first outline the various accounts to be kept, then discuss the methods of gathering the data and finally describe the method of distribution.

Fundamental Divisions of Cost.—In order to make the discussion clear, Chart No. 1 has been inserted. The subdivisions shown are only illustrative, and are not complete, since it would be futile to attempt to make a complete outline that would apply to any contracting firm. Keeping books is writing the history of business transactions; hence, it is obvious that no outline of the "history" can be made until the "events" are known. Even though two firms are in the same line of work, these "events" are never of quite the same nature in both concerns. Therefore, it is clear that before an outline of the records of a concern can be made, that particular concern must be studied to learn the nature of all its transactions. For this reason no general discussion of the methods of keeping accounts for any line of business can hope to be more than thoroughly suggestive.

Every source of expense to a contracting business contributes to the total cost of the contracts carried by the firm. A certain proportion of the Office Rent, the Legal Expenses in connection with law suits, the cost of making unsuccessful tenders, etc., are just as much a part of the cost as wages paid to carpenters and bricklayers. To allocate these various costs seems a difficult problem, but the first step is simple, for each item can be readily classified under one of the following two divisions:

1. Direct Expense.
2. Overhead Expense.

Direct Expense includes all expenditures that pertain to only one contract, and that can be charged to that contract without subdivision or apportionment.

Overhead Expense includes all expenditures that pertain to all the contracts carried, and that cannot be charged to the individuals contracts without subdivision or apportionment.

Analysis of Direct Expense Account.—The Direct-expense Account is divided into two parts:

1. Field Expense.
2. Sub-Contract Expense.

Field Expense includes all items which can be directly charged to the work in the field.

Sub-Contract Expense includes all amounts paid for work done by sub-contractors.

Under Field Expense we have four subdivisions:

1. Labor.
2. Materials.
3. Supplies.
4. Miscellaneous.

All expense for labor (except when sub-contracted) employed in the field is charged under *Labor.*

Expenditures for materials which are found in the completed structure, and which are paid for according to the contract, are charged under *Materials; e.g.*, Cement, Sand, Crushed Stone, Bricks, etc.

Supplies include all such items of material as are necessary to the carrying on of the work, but which are partially, or wholly, destroyed in the process of construction; *e.g.*, Oil, Waste, Coal, Rope, Hose, etc.

General items of expense which do not come under any of the first three classifications, but which can be directly charged to the Field Account of a contract, come under *Miscellaneous; e.g.*, Plant Rental, Plant Depreciation, Telephone and Telegraph, Postage, etc.

Analysis of Overhead Expense Account.—There are two main divisions under Overhead Expense:

1. Office Expense.
2. General Miscellaneous Expense.

Office Expense includes all items which cannot be charged directly against the field and which are due to maintaining an office.

Three subdivisions can be made under Office Expense, namely:

1. Labor.
2. Supplies.
3. Miscellaneous.

All expenses incurred for *Labor* through the office force, including everybody housed in the office from the Manager down to the Office Boy, are classed under Office Labor. In the case of a large business it will pay to subdivide this account rather minutely, the degree of analysis depending upon the magnitude of the business. In a small firm, where a man is called upon to do several classes of work, time of the individuals will have to be divided and charged to several classifications. This matter will be taken up again later.

Supplies include all expenditures for materials used by the office force, and include such items as Engineer's Supplies, Bookkeeper's Supplies, Stenographer's Supplies, etc.

Expenditures which are due to the maintenance of the office and which cannot be classed under either Labor or Supplies, being general in nature, are charged under *Miscellaneous Expense.*

General Miscellaneous Expense includes all expenditures which are so general in nature that it is impossible to charge them against either the Field or the Office and which are due to the maintenance of the business in general.

The various items of the subdivisions under Field, Sub-Contract and Office Expense are divided into three classes:

1. Management Costs.
2. Maintenance and Incidental Costs.
3. Direct Costs.

Management Costs include all expenditures for labor doing work of a managerial nature, involving discretionary powers.

Maintenance and Incidental Costs include all expenditures incurred by the Office and Field for labor, material, supplies and miscellaneous items necessary to the maintenance of the business, but incidental as regards the actual construction.

Direct Costs include all expenditures for labor, materials, supplies and sub-contracts directly necessary in carrying out the main contract.

Attention is called to the fact that the Total Expenditures are equal to the Total Construction Costs. Hence, when unit costs are worked out, their total should check reasonably close with the difference between Total Expenditures and sub-Contracts, or they are too much in error to be of use. Just what "reasonably close" means depends on the class of work and on the elaborateness of the system of accounts, which in turn depends on the size of the business. On one large contract the total of the unit costs as made up from distributions checked within 1% of the costs according to the books. This work was done by a large firm with a newly installed cost department.

Gathering Data.—Field Labor data for Field Labor expense come weekly from the Timekeeper in the form of the Weekly Pay Roll. Form I is that used for the Construction Labor. For Field Management and Incidental Labor the same form is used, with the exception that the words printed at the heads of the sheets are the names of those accounts.

CON'T. No. 115. — Sheet No. 20

CONSTRUCTION LABOR

WEEKLY PAY ROLL FOR WEEK ENDING Jan. 9 1909

	Name. (Write last name first.)	Trade.	Hours. Fri.	Sat.	Sun.	Mon.	Tues.	Wed.	Thur.	Total Hours	Rate.	Amount Dollars	Cts.	Trade Total Dollars	Cts.	Remarks.
1	Murphy, Patrick	Mason	8	4		8	6	7½	8	41½	0.55	22	83			
2	Sullivan, James	"	8	4		7	6	8	8	41	0.55	22	55			
3	Oliver, Patrick	"	8	4		8	6	8	8	42	0.55	23	10			
4	Williams, Robert	"	8	4		8	6	8	8	42	0.55	23	10			
5	White, Walter	"	8	4		7½	6	8	8	41½	0.55	22	83			
6	O'Neil, Clarence	"	8	4		8	6	8	8	42	0.55	23	10			
7	O'Connel, Frederick	"	8	4		8	6	4	8	38	0.55	20	90	158	41	
8	Smith, James	Mason's Helper	8	4		7½	6	8	8	41½	0.22½	9	34			
9	Jones, John	" "	8	4		8	6	8	8	42	0.22½	9	45	18	79	
10	Smith, John	Bricklayer	8	4		8	6	8	8	42	0.55	23	10			
11	Quirk, Samuel	"	8	4		0	6	8	8	34	0.55	18	70			
12	Russel, Walter	"	8	4		8	6	8	8	42	0.55	23	10			
13	Glass, Charles	"	8	4		7	—	—	—	19	0.55	10	45			P.R.U. 510
14	Green, James	"	8	4		8	6	8	8	42	0.55	23	10			
15	Willets, Joseph	"	8	4		4	4	8	8	36	0.55	19	80			
16	Rubinstein, Isaac	"	8	4		8	6	8	8	42	0.55	23	10			
17	Dexter, James	"	8	4		8	6	8	8	42	0.55	23	10			
18	Butler, John	"	8	4		8	6	8	8	42	0.55	23	10			
19	King, George	"	8	4		8	6	8	8	42	0.55	23	10			
20	Kellogg, Frank	"	8	4		8	6	8	8	42	0.55	23	10			
21	Cole, John	"	8	4		8	—	—	—	20	0.55	11	00			P.R.U. 511
22	Coleman, James	"	8	4		8	6	8	8	42	0.55	23	10			
23	Brown, Frank	"	8	4		7	6	8	8	41	0.55	22	55			
24	Franklin, Joseph	"	8	4		8	6	8	8	42	0.55	23	10			
25	Haring, Frederick	"	8	4		8	6	8	8	42	0.55	23	10			
26	Homer, George	"	8	4		8	6	8	8	42	0.55	23	10			
27	James, John	"	8	4		8	6	8	8	42	0.55	23	10			
28	Conners, James	"	8	4		8	6	8	8	42	0.55	23	10	405	90	
29	Murphee, James	Bricklayer's Helper	8	4		8	6	8	8	42	0.22½	9	45			
30	Carber, John	"	8	4		9	6	8	8	43	0.22½	9	68			
31	Lucas, James	"	8	4		8	6	9	8	43	0.22½	9	68	28	81	
32																
33																
34																
35																
36																
37																
38																
39																
40																
	Sheet Totals.											611	91	611	91	

Posted to Distribution Sheet.
U.S.N. Le 100
S.M.H. Book keeper

This account is correct.
James S. Smith Time Keeper.
Approved C. B. Mims Supt.

Form I.

It will be noted that the week ends on Thursday night. This is to give the Timekeeper Friday and Saturday in which to make up his accounts and get his money ready for payment on Saturday night. Anyone who has been through those week-end periods knows that this is not allowing any too much time.

The men are listed according to trades, and the total amount paid for the week to each trade is entered in the "Trade Total" column on the line opposite the last name in that list. When starting to list a trade on a sheet partly filled, take a new sheet if there is not room for the whole trade in the remaining space.

CONTRACT No. *115* P. R. V. No. **510**

WEEKLY PAY ROLL VOUCHER

Class of Work *Bricklayer* Date *Jan. 6* 190*9*

Name *Chas. Glass* No. ~~~

Fri.	Sat.	Sun.	Mon.	Tues.	Wed.	Thur.	Total Hours	Rate	Amount	
8	*4*	—	*7*	—	—	—	*19*	*0.55*	*10*	*45*

RECEIVED OF THE REAL ESTATE CONSTRUCTION COMPANY

~~~~~~~~~~~~~~ *Ten* ~~~~~~~~~~~~~~ $\frac{45}{100}$ DOLLARS

Chas. Glass
Workman's Signature

CORRECT *James S. Smith*
Time Keeper

APPROVED *A. B. Minns*
Superintendent

Form II.

When a man is discharged and paid during the week a voucher such as shown by Form II should be obtained and the voucher number entered in the "Remarks" column of the weekly pay roll. See Form II.

All of these forms should be made up into books of convenient size with alternate pages printed on thin paper, and a carbon sheet used to make a copy on the thin sheets. The original sheet is perforated near the binding so that it can be readily torn out and forwarded to the Office. A copy of all records is thus left in the book for reference on the work.
~~~~~~~~~~~~~~

Later, under the discussion of distribution, the further handling of these data will be taken up.

Office Labor.—The time of the owner who attends to the business end will be divided between soliciting new business, purchasing materials, interviews with owners and architects, legal matters and various other things too numerous to mention. To be able to tell just how much each of these items costs the business might be very interesting, but the value of such data would not justify its expense and trouble in collecting. Hence, his salary will be charged each month without being analyzed.

In the case of the other owner it would seem advisable to distribute the time over Estimating, Designing and Superintendence. The division is simple and inclusive; and the information gained is of value, because it helps to keep the constructive accounts of Superintendence and Estimating accurate. As the major part of the time will be charged to Superintendence, the additional work will be slight.

Monthly wages paid to the Estimator, Bookkeeper, Stenographer and Office Boy can be readily charged to their respective accounts each month.

Field Materials.—Wise purchasing of material is as dependent upon effective Material Accounts as efficient management of labor is on Labor Accounts. The partner whose duty it is to purchase materials might succeed in getting good prices, but without some system he would be unable to follow up each purchase to see that the quality and quantity that he contracted for were delivered, that the materials were billed but once, and that the price as billed was the same as the agreed price. But the average man would not be able even to get good prices, because successful purchasing, like the letting of contracts, is not a question of picking the lowest bidder, but of carefully comparing values. Good judgment is a prerequisite; and with such a vast amount of detail, it is impossible to bring good judgment to the problem without some aid to the memory. For example, if coal is to be purchased, some of the questions which the purchaser should be able to answer are:

Of whom have we purchased coal before?

What were the prices?

Was the quality of coal delivered satisfactory?

Was the quantity as ordered?

Was the service prompt?

With such an important item as coal it may be easy to remember the leading facts. But there are thousands of items to be dealt with, and no one is able to remember the detail necessary to good judgment in purchasing in such a wide field. The return in savings on purchases will more than pay for the extra cost of keeping what the small contractor may consider too elaborate a system of Material Accounts.

Purchasing.—First, let us outline the various steps in purchasing; and in order to make the outline general, let us take the case in which the Purchaser must be notified of the need of material. For example, the hoisting engineer reports to the Timekeeper that he needs oil for his engine. The latter makes out a Purchase Requisition for the oil,—which is a notice that certain quantities of that material are needed,—and sends it to the Purchaser after it has been signed by the Superintendent. On receipt of the Requisition the Purchaser selects a Dealer and issues a Purchase Order for the oil. A copy of this is sent to the Timekeeper, who checks off the items when the material is received. By means of a Receiving Slip he notifies the Purchaser that the goods ordered have arrived. In general this is the method of making purchases.

Stock forms for the work outlined above can be purchased of firms dealing in office records. They will serve the purpose quite well; but, of course, it is always more satisfactory to have special forms printed when possible, because the stock forms are of necessity general and cannot meet the special demands peculiar to the business.

Purchase Requisition.—Purchase Requisitions should give such information as Contract Number, Requisition Number and Date, Point of Delivery, Quantity and Description of Material, Proposed Use, Date Wanted, Timekeeper's and Superintendent's Names. Also, space should be provided for the Purchaser's record of the firm from which the material was ordered and the number of the Purchase Order. They should be made in duplicate so that the copy may be kept on file at the job. Until a copy of the Purchase Order arrives this duplicate serves as a reminder that the materials needed have not yet been ordered. If, for any reason, the order is not placed promptly, the delay will be shown by the Requisition File, and a note of it made in the Daily Letter will correct the fault. This is a letter to the Office written each night by the Timekeeper and signed by the Superintendent, and

should contain a statement of progress made during the day and any items of special interest to the Office.

Purchase Order.—Purchase Orders should give such information as Contract Number, Order Number, Date, Purchase Requisition Number, Dealer's Name, Place of Delivery, Proposed Use of Materials, Method of Shipment. They should be made in triplicate. The original goes to the Dealer as his authority for shipment, and gives him the identifying number to place upon his shipments and bills. In cases where the order arises out of a requisition, as in the case cited above, the duplicate goes to the department which made the requisition to give notice that the materials needed have been ordered. This leaves the triplicate for the Purchaser's record. It is usual to make these three copies of different colors, so that the department from which a paper comes may be told at a glance. Thin paper is used for the original and duplicate, and the triplicate is on a regulation card for filing. Hence, all three copies can be made at one time by the use of carbon sheets. By having thirty-one numbers printed horizontally along the top of the card the day of promised delivery may be indicated by attaching an adjustable tab showing the month at the point where the date of delivery is printed. This enables the Purchaser to tell at a glance what orders are overdue, and thus avoid delays.

It is not advisable to put the price on the Order. In the case of most of the small purchases the price is not known, the Purchaser relying on the past fair dealing of the Dealer for a reasonable figure. Before he pays for the goods he will, of course, determine whether the price is right or not; but if he waited to find out the price before ordering, his work would be seriously delayed to the detriment of the business.

Receiving Slip.—Receiving Slips should give such information as Contract, Order and Receiving Slip Numbers, Date of Receipt of Materials, Shortage or Mistake, Quantity and Description of Materials. They should be made out in duplicate, the original going to the Purchaser to notify him of the receipt of the materials that he ordered, and the duplicate remaining on the job. In case several shipments are necessary to make up the order, each separate delivery should be immediately reported on one of these slips; and on receipt of the final shipment, a note to that effect should be made on the slip reporting the receipt of the materials. As the several Receiving Slips come in, the Pur-

chaser attaches them to the copy of the Purchase Order which authorized the shipment of the goods received. When the final Receiving Slip comes in he records on the Order the prices that have not already been recorded and "O.K's" it ready for checking the bills. If the Dealer does not deliver promptly the Purchaser will be notified of the fact by the Purchase Order which will be in his file of unfilled orders without a final Receiving Slip.

Duplicate Bills.—Duplicate bills bearing the Purchase Order number may be demanded of vendors in certain cases. One is filed alphabetically and the other numerically, so that a bill can be found as readily when only the number is known as when the name of the vendor is known.

Combined Purchase Requisition and Order.—There is a modification of the purchasing system outlined above which, if the conditions are favorable for its adoption, will save considerable time. The Purchase Requisition and Purchase Order are combined into one sheet, so that when the Requisition comes to the Purchaser he has simply to fill in the name of the Dealer. By the use of carbon sheets the Timekeeper makes five copies. One of these copies remains in the book for reference on the job and the other three, with the orginal, are forwarded to the Purchaser. The latter enters the name of the Dealer on the four sheets by means of carbon paper and sends the orginal to him as his authority for the sale. One of the copies goes back to the source of the demand to give notice of the purchase, and the other two copies remain with the Purchaser for alphabetical and numerical filing. As the materials purchased arrive, Receiving Slips are sent to the Purchaser, and when the final shipment is received, the copy of the Order sent to the job by the Purchaser is returned to him with a note stating that the final delivery has been made and calling attention to faulty material or shortages.

Price Records.—As these accounts are designed for a small contractor, it is safe to presume that he confines his activities to a few cities, or even to one city. If this is the case, his purchases are made among a certain limited field of dealers. Hence, it will pay him to keep record cards showing the comparison of quotations on different staple articles. In this way he will be able to determine accurately the best place to purchase.

The quantity and quality of each class of Construction Materials will be determined from the drawings and specifications

by the engineering department, who will inform the Purchaser as to what is necessary. The purchasing of these materials offers a big opportunity for saving and will have to be handled by the Purchaser himself.

Field Supplies.—Many of the purchases of Construction Supplies will find their origin in a Purchase Requisition from the job. But it is necessary, in order to avoid great loss through delays, that the Timekeeper be authorized to make out Purchase Orders for such supplies as Nails, Rope, Brooms, Hose, etc., for immediate delivery. All such Orders should bear a distinctive mark and a serial number and be approved by the Superintendent. The method is the same as already outlined for regular purchases through the Purchaser. In this case, however, a copy of the Order goes from the job to the Purchaser, instead of from the Purchaser to the job.

If the contract is very large it will pay to maintain a Storeroom on the job, with a Storekeeper in charge. He should keep as careful records of the material received and disbursed as the work will allow. This in itself is a topic for elaborate discussion and space cannot be given to it in this chapter.

Tool Record.—A Tool Record of some kind should be kept by every contractor no matter how small the job. Even if it is only an approximation to a correct record it will serve a good purpose, for if there are signs that records are being kept, the workmen will not know how accurate they are and will hesitate to appropriate tools for fear that the records will show their misdeeds. Just a simple record charging tools sent to the job and crediting those returned to the Storehouse or transferred to another job will save a great deal of money. If a Purchase Requisition comes in calling for tools for a certain sort and the Tool Record shows that a normal number have already been supplied to the job, the fact can be called to the attention of the Superintendent and a reason demanded for the necessity of such a large supply.

Office Supplies.—Whether the firm be large or small, it is advisable to leave the purchasing or drafting and stenographic supplies to those departments, with the occasional supervision of the regular purchasing head. No one knows so well as the persons doing the work in these departments just what particular kind of material is needed. Also, when special technical knowledge is of value in making a purchase it is wise to allow the

proper department to place its own order. But for every purchase there should be a Purchase Order issued by the Purchaser or somebody authorized by him.

Plant Depreciation.—Whether a contractor's plant is in use or in storage it is depreciating in value. Even the moment an article is purchased its value drops, because the article immediately becomes second-hand. If the loss in value of plant due to depreciation is not taken out of the gross profits and either put back into the business or used to establish a fund with which to purchase new plant when that now in use must be discarded, the capital is being impaired and the business ruined.

Until recently it was customary to charge out a certain percentage of the value of the plant at the end of the year in the Profit and Loss Account; but this method does not give the correct cost of each separate piece of work, because each job has the use of certain plant and should bear a proportion of the total depreciation.

One modern method of handling this account is to credit the Equipment Account and charge an Equipment Depreciation Suspense Account, with the estimated amount of depreciation for the coming year. Then the value of the business for the coming year is estimated, and as each contract is completed it is charged with a part of the total depreciation for the year determined by the ratio of the value of the contract to the estimated business for the year, and the Equipment Depreciation Suspense Account is credited with the same amount.

This scheme presents several difficulties. In the first place, the amount of plant that will be carried during the year is unknown, and hence the per cent. for depreciation cannot be accurately determined. Also, the amount of business which will be done during the coming year is an unknown quantity. Again, if you charge a certain proportion of the depreciation on all plant to a contract, whether the total of that proportional part of the entire plant was used on the job or part was used and part was in storage, the amount of depreciation which you charge to a contract this year when business is dull will be quite a different amount from what you would charge for the same piece of work next year when all your plant is in use. In other words, if this method is used the records will lose their value for comparisons.

It may be argued, as above, that it costs a contractor the total amount of the depreciation to maintain his business, and that as

he does so much business with that amount as one of the items of expense, each part of the business done costs its proportion of the total depreciation. Nevertheless, what it costs a contractor to maintain his business and what it costs him to perform the contracts of the year are quite different. For example, if he obtained no contracts at all for a year he would still have a considerable item for Equipment Depreciation, and this would have to be charged to maintaining his business. When his plant is not all in use, that part of the depreciation which is on account of plant in storage is a part of the expense of maintaining his business and not a part of the cost of performing the contracts in hand. The reason why some advocate this proportional method is that they confuse the point of view; they look at the question from the point of view of an outsider, rather than that of the contractor. An outsider knows that a contractor must at least make enough on his contracts to cover the total expenses, and that if work is being done the owner is going to help to pay those expenses. Thus, to the outsider, a ratable proportion of the expense for depreciation will be charged to the work being done for him, and it will be; but the contractor wants his accounts to tell what it costs for the depreciation of the plant actually used in the completion of the contract, so that the figures will be useful in estimating on future work; also, what it costs to carry idle plant in order to remain in business.

This information can be readily obtained if the proper method is followed. Some record of the equipment on the work and in storage must be kept in any event. Also, a schedule of depreciation rates for the different items of plant must be made out, if anything like an accurate charge for depreciation is to be made. If the monthly depreciation rate is entered opposite each plant charge to the different jobs and storage accounts, this can readily be multiplied by the time during which the item of plant remains charged and the amount of depreciation entered in the column next to the rate. The total of the amount column can then be charged to the job in case the plant is in use, or it can be carried into a Profit and Loss Account in case the plant is in storage. This method is even simpler of operation than the first one described.

It is, of course, obvious that if plant is carefully repaired its life may be indefinitely extended, and hence the rate of depreciation lowered. Just how much a certain piece of plant will be

repaired cannot be predicted; but if we should credit out the cost of all repairs except those due to accidents, unforeseen breakdowns, etc., against the charges for depreciation, we would practically charge off depreciation at this modified rate. If we charge depreciation at some arbitrary rate and then also charge the business with repairs which counteract the effect of depreciation, it is clear that we are overloading with expense, because we are charging depreciation at an excessive rate. But there are so many difficulties in separating the expenses for repairs into those that should be credited in the Depreciation Account and those that should be charged against Repairs, that it seems better for the small contractor to charge all against Repairs. In handling the account in this way he is, at least, on the safe side financially.

Interest on Plant.—Contractors doing work on the cost-plus-a-fixed-sum or the cost-plus-a-percentage, basis are anxious—and justly so—to include among the items of cost the interest on the money invested in the plant used on the work. By following the usual method of simply charging off among the Overhead Expenses a certain percentage of the total capital as interest, the interest on the money invested in plant is finally charged against the several contracts because it swells the percentage charge for Overhead Expense. But the amount which is charged to each job is not based on the ratio between the plant used on the job and the total plant owned by the contractor; hence the charge may be unjust and open to objection on the part of the person for whom the work is being done. If it is true in this case, it is also obvious that the contractor doing work on the ordinary contract basis is not arriving at its true cost if he follows this method of charging interest.

If a column is provided next to that for depreciation in the scheme outlined above for handling Depreciation, the charge for interest can be entered as easily as that for depreciation, and the total charged off against the job.

Interest on capital in other forms necessary to the business will have to be charged off through Overhead Expense. The amount of this charge will be equal to the difference between the interest on the total capital and the total of the plant interest charged to the several jobs.

Electricity Purchased.—In case steam and electricity are bought from outside concerns we will have bills coming in for

steam and electricity in addition to those for water. A note of the reading of each meter should be made periodically on a job Purchase Order and forwarded to the main office as if a purchase had been made.

Liability Insurance.—Insurance on employees is figured on the weekly pay roll, and a Purchase Order should be made out for the amount when the pay roll comes into the office. Timekeepers' Bonds and all other items of expense of a similar nature, the amount of which is definitely known before the bills come in, can be handled in the same way. When the bills are received they can thus be checked in the same way as for purchases, and shere will be no danger of paying the same bill twice.

Miscellaneous Office Expense.—The items that go to make up the Miscellaneous Expense Account are comparatively few in number. Their nature is such that they do not lend themselves to the methods already outlined for collecting items of expense. As the bills come in for Rent, Telephone and Telegraph, Insurance, etc., they are referred to the proper persons for their "O. K.," and a glance at the account books, contracts, leases and other papers will establish the justness of the claim.

Such small items as Postage and Car Fares can best be handled through a Petty Cash Account. A certain amount of cash, to be determined by the previous experience of the business, is turned over to one in charge of this account and is charged on its records. All expenditures are credited to the account and vouchers obtained. Either periodically, or when the cash on hand reaches a certain low figure, the vouchers are turned in and cash to the amount of their total paid into the Petty Cash Fund.

This amount plus the cash on hand should always equal the original amount assigned to the account.

Sub-contracts.—The amount of expense due to parts of the main contract being sub-let can, of course, be obtained from the contracts.

General Miscellaneous Expense.—What has been said of the items under Miscellaneous Office Expenses applies equally well to those found under General Miscellaneous Expense.

Distribution of Expenditures.—We have now described the various accounts and discussed the methods of gathering the data for them. But only a small percentage of the value of these data could be realized if the accounting work were dropped at this point. It still remains for us so to group and arrange these

CONTRACT No. 115. CONSTRUCTION FIELD MATERIALS DISTRIBUTION SHEET. FL

Date.	1 Lumber.			2 Cement.			3 Sand.			4 Crushed Stone.			5			Total.
	Purchase Order No.	Amount.	√	Purchase Order No.	Amount.	√	Purchase Order No.	Amount.	√	Purchase Order No.	Amount.	√	Purchase Order No.	Amount.	√	

Form III.

SUMMARY SHEET.
OVERHEAD EXPENSE.

Date.	Office Expense.																					Gen'l Miscellaneous Expense.							Total Overhead Expense.
	Office Labor.								Office Supplies.					Office Miscellaneous.						Total Office Expense.									
	Manager.	Chief Engin'r.	Estimator.	Bookkeeper.	Stenographer.	Office Boy.	Etc.	Total.	Engineers' Supplies.	Bookkeeper's Supplies.	Stenographer's Supplies.	Etc.	Total.	Tel. and Tel.	Postage.	Rent.	Traveling.	Etc.	Total.		Charity.	Insurance.	Interest.	Advertising.	Legal Services.	Etc.	Total General Miscellaneous Expense.		

Form V.

data that they will show at a glance the expense of the different divisions of the work.

Columnar ruled Distribution Sheets afford the best solution of the problem of distributing expenditures. (See Form III.) These are simply sheets headed with the names of the general accounts to be charged and ruled with vertical columns for the amounts to be entered under the subdivisions of the general accounts. At the extreme left hand side is a column for the date, the smaller column to the left of each amount column is for the number originally put on the Purchase Order, and the very narrow column to the right of each amount column is for tick marks in checking.

In the following Schedule for Distribution of Expenditures the items found in the second subdivisions and marked (1), (2), (3), etc., will be the headings for distribution sheets; *e.g.*, Field Management, Field Incidental, Construction. Items found in the third subdivisions and marked (*a*), (*b*), (*c*), etc., will be headings for the columns; *e.g.*, Superintendent, Assistant Superintendent, Mason Foremen, etc.

When a bill is checked and ready for payment it should show on its back the total expenditure distributed over the various items of which it is composed. By using a system of symbols, such as shown to the right of the schedule below, we are able to designate with little labor both the account to which an item should be posted and also its location in the records.

Schedule of Distribution of Expenditures

I—Direct Expense.

(*A*) Field Labor.

1. Field Management	115-FF
(*a*) Superintendent	115-FF-1
(*b*) Assistant Superintendents	115-FF-2
(*c*) Mason Foremen	115-FF-3
(*d*) Bricklayer Foremen	115-FF-4
(*e*) Carpenter Foremen	115-FF-5
etc.	
2. Field Incidental	115-FI
(*a*) Time keeper	115-FI-1
(*b*) Night Watchman	115-FI-2
(*c*) Day Watchman	115-FI-3
(*d*) Water Boy	115-FI-4
etc.	

3. Construction 115-FL
    (*a*) Masons 115-FL-1
    (*b*) Bricklayers 115-FL-2
    (*c*) Carpenters 115-FL-3
        etc.

(*B*) Field Materials
1. Construction 115-FM
    (*a*) Lumber 115-FM-1
    (*b*) Cement 115-FM-2
    (*c*) Sand 115-FM-3
    (*d*) Crushed Stone 115-FM-4
    (*e*) Brick 115-FM-5
        etc.

(*C*) Field Supplies.
1. Construction 115-FS
    (*a*) 115-FS-1
    (*b*) 115-FS-2
    (*c*) 115-FS-3

(*D*) Field Miscellaneous Expense.
(1) Incidental 115-FX
    (a) Photographs 115-FX-1
    (*b*) Insurance 115-FX-2
    (*c*) Plant Rental 115-FX-3
    (*d*) Plant Interest 115-FX-4
    (*e*) Plant Depreciation 115-FX-5
        etc.

(*E*) Sub-Contracts.
1. Construction 115-FU
    (*a*) Roofing 115-FU-1
    (*b*) Excavation 115-FU-2
    (*c*) Plumbing 115-FU-3
        etc.

II—Overhead Expense.

(*A*) Office Labor.
1. Management . . . . OD
    (*a*) Manager OD-1
    (*b*) Chief Engineer OD-2
    (*c*) Estimator OD-3
    (*d*) Book keeper OD-4
    (*e*) Stenographer OD-5
    (*f*) Office Boy OD-6
        etc.

(*B*) Office Supplies.
1. Incidental . . . . OS
    (*a*) Engineers' Supplies OS-1
    (*b*) Book keeper's Supplies OS-2
    (*c*) Stenographer's Supplies OS-3
        etc.

(*C*) Miscellaneous Expense.

1. Incidental .... OX-
   - (*a*) Telephone and Telegraph OX-1
   - (*b*) Postage OX-2
   - (*c*) Rent OX-3
   - (*d*) Traveling OX-4
   - etc.

(*D*) General Miscellaneous Overhead Expense XX

- (*a*) Charity XX-1
- (*b*) Insurance XX-2
- (*c*) Interest XX-3
- .... (*d*) Advertising XX-4
- (*e*) Legal Services XX-5
- etc.

Hence once the distribution has been written on the back of the bill, the remaining work is merely mechanical; for, by simply glancing at the back of the bill, the bookkeper is able to turn immediately to the column in which the amount is to be entered.

In this system the first number is that of the contract to which the charge goes. Of course, this number will not appear in the symbols of the accounts under Overhead Expense, as these are not directly chargeable to the individual contracts. The method of handling these accounts will be made clear when we come to discuss the Profit and Loss accounts. Following the contract number are two mnemonic symbols which show the subdivision of the accounts under which the item comes, and the distribution sheet on which it is to be charged. The number following indicates the column in which the amount to be charged to the sheet should be entered.

To illustrate, let us suppose that a bill has come in for—

200 ft. ⅝ in. wire rope, at 10 cts.	$20.00
50 lbs. "Slip Easy," at 3 cts.	1.50
50 window weights, at 15 cts.	7.50
	$29.00

On the back of the bill the bookkeeper would write:

115-FS-3	$21.50
115-FM-12	7.50
	$29.00

When he was ready to post these amounts he would turn to the Field Supplies Sheet for Contract 115 and enter $21.50. Then

he would post $7.50 in column 12 of the Construction Material Sheet for Contract 115. The accounts with Field Supplies and Construction Materials are subdivided, so as to give data on the various supplies and materials. Subdivision of this kind depends entirely on the particular needs of the work, and the business of each firm has to be studied before they can be made.

From week to week, as the pay-roll statements come in from the Timekeeper, the Trade Totals are transferred by the Bookkeeper to their respective summary sheets, as shown by Form IV, page 280. After each entry the total to date is written in small figures with red ink under the entry. The Trade Totals for the week are added and the result placed in the Weekly Total column. This amount is then added to the Grand Total for last week, which gives the total cost to date. This method of handling the accounts makes it possible to tell on Monday morning how much has been expended on any contract for Construction, Incidental and Management Labor up to the preceding Thursday night; it tells how much these items cost for any week; and it gives the total amount paid for any single item of labor for anv week, for any number of weeks, or to date.

On the Sub-contract Distribution Sheet a column is assigned each contract. As payments are made for the value of the completed work less a percentage, the net amounts are entered in their respective columns. The total amount of the contract is entered in the heading of the column. Knowing the percentage, it is an easy matter to tell at any time how a contract stands. To those who are inseparably attached to debits and credits this may sound childish because of its simplicity; but it is a very practical method in use on large contracts.

Summary Sheet.—Every month the totals from distribution sheets of each contract are posted to their respective Summary Sheets. Column headings for such sheets are shown by Form V, page 275. By writing the totals of each column in small figures under each entry we are able to read the totals to date for each column as well as the monthly totals.

Profit and Loss Accounts.—As stated before, it is impossible to charge the items under Overhead Expense directly to the contracts. If we knew how much business we were going to carry during the year we could charge off against each contract a proportion of the Overhead Expense determined by the ratio of the contract price to the total amount of the year's contracts.

Contract No. 115 CONSTRUCTION LABOR DISTRIBUTION SHEET. F.L.

Sheet Nos.	Week	1 Masons.	2 Mason Tenders	3 Bricklayers	4 Bricklayers Tenders	5 Carpenters	6 Plasterers		7 Riggers	8 Pipe Fitters	Pipe Fitters Tenders	10 Laborers	11 Etc.	12	13	14	Weekly Total	Grand Total
1-2	Oct. 16 1908 to Oct 23 1908					115 18			33 10			213 17					361 45	361 45
2-3	" 23 1908 to " 30 1908					120 40			39 31			290 80					450 61	811 96
3-4	" 30 1908 to Nov 6 1908	175 10	10 80	223 15	10 80	180 85			51 08			356 16					1007 94	1819 90
4-5	Nov. 6 1908 to " 13 1908	228 40	21 60	460 90	21 60	193 10			90 42			374 09					1390 11	3210 01
5-6-7	" 13 1908 to " 20 1908	225 65	21 60	590 10	21 60	210 40			87 69	68 92	10 80	325 10					1561 86	4771 87
7-8-9	" 20 1908 to " 27 1908	235 80	21 60	630 25	32 40	230 03			89 43	75 45	10 80	350 02					1675 78	6447 65
9-10-11	" 27 1908 to Dec 4 1908	235 20	21 60	638 40	33 08	255 89			95 62	89 60	10 80	359 10					1739 29	8186 94
11-12-13	Dec. 4 1908 to " 11 1908	230 59	21 60	633 05	32 40	245 92	58 92		87 50	93 87	10 80	365 08					1779 68	9966 62
13-16	" 11 1908 to " 18 1908	238 45	25 40	628 40	32 40	250 98	43 60		89 63	85 32	11 95	360 89					1767 02	11733 64
16-17-18	" 18 1908 to " 25 1908	234 90	21 60	575 10	21 60	249 60	57 89		87 12	89 92	10 80	358 92					1702 45	13436 09
18-19-20	" 26 1908 to Jan. 2 1908	215 70	23 50	509 35	21 60	247 53	45 10		86 39	89 39	12 30	369 88					1620 74	15056 83
20-21-22	Jan 2 1908 to " 9 1908	158 41	18 79	405 90	28 81	145 03			98 42	43 10	10 80	250 79					1160 00	16216 83
23	" 9 1908 to " 16 1908			150 05	10 80				95 33	25 02	10 80	187 39					479 39	16696 22
24	" 16 1908 to " 23 1908								52 89			115 43					168 32	16864 54
	190 to 190																	
	190 to 190																	
	190 to 190																	
	190 to 190																	
	190 to 190																	
	190 to 190																	
	190 to 190																	
	190 to 190																	
	190 to 190																	

Form IV.

Unfortunately there is no way of determining this unknown variable. And even if we could, the result obtained by the method just outlined would not be correct, because some of this expense is due to the contracts handled and some to maintaining the business. Should no contracts be carried for a year, the entire amount of this expense would have to be charged against maintaining the business, for there would be no contracts to charge it against.

The only way to handle the Overhead Expense Account is to close it into a Miscellaneous Profit and Loss Account. Depreciation of plant in storage should also be closed into the account. This account will show a big loss, as the only credit will be Discounts Gained and some small miscellaneous items.

Field and Sub-contract Costs are added together for each contract and these totals closed into a Contract Profit and Loss Account. In this case the credit side will be large and a big gain will be shown, which should more than offset the loss in the other account.

Finally, these two Profit and Loss Accounts are closed into a Surplus Profit and Loss Account, which shows the loss or gain for the month.

In making up the unit costs as the work progresses, a certain percentage of the Field Costs can be added for Overhead Expense. The percentage for this approximation can be determined from the previous experience of the business.

It would be necessary to devote an entire book to the subject of contractor's accounts in order to treat of it fully. Even with such an amount of available space, the discussion could not hope to be more than suggestive, because each individual business must be studied in order to design accounts to meet its particular needs. Hence, it is clear that this short chapter is only an outline. Many points have been barely touched upon and some have been omitted altogether, but if the discussion has made it clear to the small contractor how he can improve his accounting work it has accomplished its purpose.

Equipment Account.—Benjamin L. Lathrop gives the following suggestions in *Engineering Record*, July 8, 1916:

A ledger account may be kept for the portable equipment of each job, but ordinarily a more convenient method is to run only one account, which for the sake of brevity we will call "Plant." Portable plant, being shipped about from job to job,

is rather difficult to keep track of unless some definite, easily operated system is employed. A card record supplies the simplest solution. Cards measuring 3 by 5 in. are the standard size, fitting the box files or drawer units handled by most dealers in office supplies. If economy demand that for a time such records be kept in a pigeon-hole of the desk, or even in a pasteboard box, at least be sure a start is made with the proper-sized card, so that all the matter will not have to be rewritten later. Index cards can be procured with ¼-in. tabs.

```
BUCKET
     1 Special No. 10—cost $90.00
     Bought Aug. 1, 1914 of
               Dayton Supply Co.
     for Acton work
     Transferred Jan. 5, 1915 to Portland
         "       Sept. 10, 1915 to Bridge No. 4
```

```
DERRICK
     1 Stiff-leg, 22′ mast 38′ boom
     Bought Sept. 1, 1915, second hand, of
               Smith & Co. for $120.00
     for Bridge No. 4
```

```
MIXER
     1 Burke Gasoline Concrete Mixer
     Bought Feb. 12, 1915, of D. E. Francis
                    for $800.00
     for Portland work
     Transferred Sept. 10, 1915 to Bridge No. 4
```

Fig. 45.—Equipment file cards.

To demonstrate, let us list the equipment of our fictitious friends Messrs. Arnold, Brown & Co. On the first tab will be written "Bridge No. 4," to indicate that the cards, shown in Fig. 45, serve to list the equipment on that job. Following out here the alphabetical idea, the first cards after the index card will read somewhat as shown in the accompanying samples. Others will follow till the list of equipment at Bridge No. 4 is complete.

Then on the tab of another index card will be written "Corfu," and following that will come the cards descriptive of the Corfu

plant, and so on till the entire plant is recorded and indexed. When additional equipment is purchased, the invoice or bill of sale will be approved, entered and filed as suggested in a previous article of this series, and charged to "Plant;" at the same time a descriptive card will be prepared and placed in the index. Now, when the Bridge No. 4 mixer is moved to the job at Leeds the card is moved along, too, after noting thereon the date on which the change was made.

The plant account should be kept at cost, until such time as a complete revaluation becomes necessary. In the meantime annual depreciation should be balanced by entries to the credit of "Reserve for Depreciation," as will be explained in a subsequent article.

Small tools, such as shovels, picks, crowbars, hand drills, etc., should not be carried in the plant account, but charged to the expense incident to each contract. Should there be any salvage at the conclusion of the job, the job can be given credit at an appraised valuation and a corresponding expense charge made against the next contract on which such tools or left-over supplies may be used.

CHAPTER VIII

OFFICE APPLIANCES AND METHODS

There are many appliances which can be used in the office for the compiling of records gained in the field and which may also be useful in general office work.

Time Clocks.—An appliance which may not, in general, used in the field, but which is of immense value in the office and

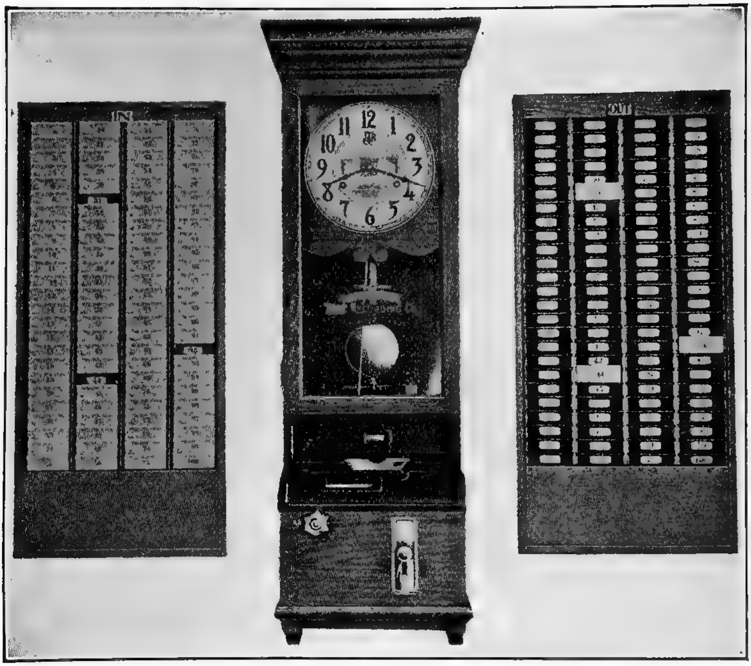


FIG. 46.—Automatic time clock with 100 card rack.

particularly in a shop, is the time clock. Various forms of time clocks are in common use, two types of which are illustrated. Figure 46 is a time card recorder, which is a clock so made that it will automatically stamp on a card inserted in a slot in the clock by the workman the time of his arrival and of his departure. The cards are made to hold a record covering the pay period and

need no attention from a timekeeper or clerk until the termination of this period. The record of the men's time can then be compiled very readily by one who need not be a skilled mathematician or time clerk.

The time clock system has been developed very highly in shops for keeping track of time used in completing any job by workmen, but as this in a way is not in the realm of field cost keeping, it will not be entered into here.

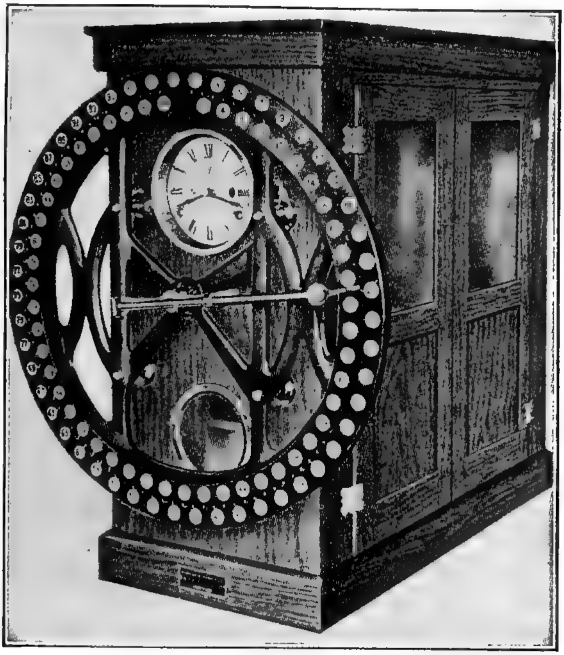


Fig. 47.—Weekly dial recorder, automatic, with two color printing device.

Another form of time clock, shown in Fig. 47, has the numbers of the employees fixed on the outer edge of a disk or ring and a record is made by the employee who shifts a revolving arm and punches his number upon entering the office and leaving. The working up of the employees' time then becomes simply a matter of computation from printed figures. These two types are made by the International Time Recording Co. of New York.

Time Clock Saves Office Work on Large Job.—An unusual office system for keeping time, checking tools and making dis-

tributions, on the contruction work of the H. Koppers Company, is given in *Engineering Record,* Dec. 9, 1916. It involves the use of a time clock, turning in of the distributions by the general foremen, and the issuing of from four to six tool checks to each man, and is said to save much office work and to give accurate results.

The men on going to work and leaving punch a slip in a time clock at the office. These slips are checked up by the timekeeper, who covers the job once during the day and sees that every man who has punched the clock is at work. From these slips the time is entered daily on the pay roll. This timekeeper does not bother with the distribution of the labor, which is turned in each night by the general foremen. Each sub-foreman is supplied with small sheets on which he writes the names and numbers of the men in his gang and a description of the work he did during the day. This takes only a short time. These slips are turned in to the general foremen before leaving, who in turn hand them to the office force. From these slips, using the proper distribution numbers, two men in the office compile the labor charges and check the pay roll.

This system simplifies the task of the timekeeper, who has only to check the time worked by the men, and also the task of the foremen, each of whom has only to put down the names of men in his gang and furnish a short description of the work done. With all the information on the desk in front of him, it is then an easy task for an office man to make the distributions and check them with the time worked. In this way three office men keep a close check on the doings of 450 workmen at a cost which ordinarily would permit of keeping only a general distribution of the time worked on different classes of construction.

Another good feature of the system is the method of checking the issuing of hand tools to the men. Each man, depending on whether he is a laborer or a mechanic, is given from four to six brass checks, each with his number on it. When he takes a shovel or a wrench from the tool house he gives up one of these checks. On a large rack on one side of the tool house are several hundred hooks, under each of a certain number of which is printed the word "Shovel," which other hooks are labeled "Pick," "Wrench," "Hammer," etc. The man's check is hung on one of the hooks labeled with the name of the tool he has taken. With he returns the tool his check is given back to him. Before

pay day, or when a man is discharged, if he cannot show all the checks issued to him the storekeeper can tell in a few seconds whether he has any tools unreturned and what they are. He can also tell at a glance how many tools of any kind are out and who borrowed them.

Electric Job Time Recorder.—A cost or time job recorder is shown in Fig. 48. This device will record the time spent on jobs. It prints the time of starting and completing a job, the latter above the former, making the process of deduction simple. The revolving dial sets the card in the proper position for printing the record.

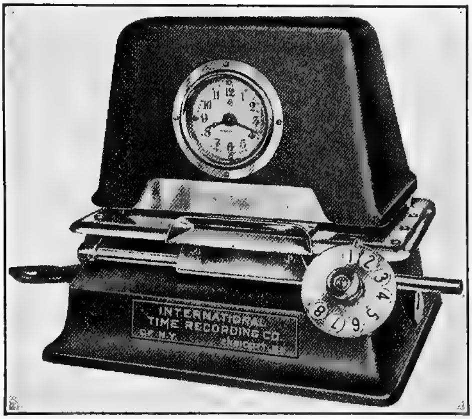


Fig. 48.—Electric job, time recorder.

This machine is made to print records in hours and minutes, or in tenths or hundredths of hours. It is equipped with an alphabetical or numerical symbol printing wheel designating either the day of the week, or date of the month, and may be had to fit any system of job recording. This machine is made by the International Time Recording Company of New York and sells for around $110 depending upon the attachments.

Time Stamp.—A time stamp that records every minute of the day and night and trips the date automatically at midnight is shown in Fig. 49. This machine may be made up to fit almost any system of timing orders, cost work or time card work. The machine weighs 15 lb. and sells for $55. Fitted with a gauge, the machine may be used to record the time of getting to work, time out and in of lunch, and quitting time of employees. With this

attachment the cost is $65. The machine is made by the Follett Time Recording Company of New York.

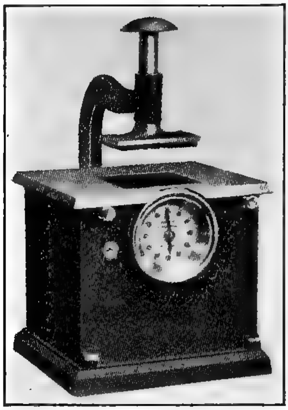
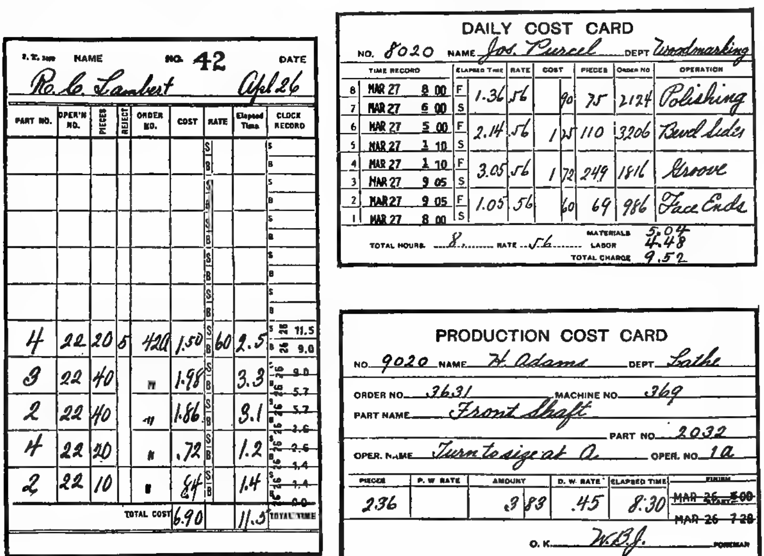


Fig. 49.—Follett time stamp.

Either of the two machines described above can place a stamp upon papers received in the office and show the hour and minute



NAME R. C. Lambert NO. 42 DATE Apl 26

PART NO.	OPER'N NO.	PIECES	REJECT	ORDER NO.	COST	RATE	Elapsed Time	CLOCK RECORD
						S B		S B
						S B		S B
						S B		S B
						S B		S B
						S B		S B
4	22	20	5	420	1.50	60	2.5	S 26 11.5 B 26 9.0
3	22	40		"	1.98		3.3	26 9.0 26 5.7
2	22	40		"	1.86		3.1	26 5.7 26 3.6
4	22	20		"	.72		1.2	26 2.6 26 1.4
2	22	10		"	.84		1.4	26 1.4 26 0.0
				TOTAL COST	6.90		11.5	TOTAL TIME

DAILY COST CARD

NO. 8020 NAME Jos. Purcel DEPT Woodmarking

	TIME RECORD		ELAPSED TIME	RATE	COST	PIECES	ORDER NO	OPERATION
8	MAR 27 8 00	F	1.36	56	90	75	2124	Polishing
7	MAR 27 6 00	S						
6	MAR 27 5 00	F	2.14	56	1 25	110	3206	Bend Sides
5	MAR 27 1 10	S						
4	MAR 27 1 10	F	3.05	56	1 72	249	1816	Groove
3	MAR 27 9 05	S						
2	MAR 27 9 05	F	1.05	56	60	69	986	Face Ends
1	MAR 27 8 00	S						

TOTAL HOURS 8 RATE 56 MATERIALS 5.04 LABOR 4.48 TOTAL CHARGE 9.52

PRODUCTION COST CARD

NO. 9020 NAME H. Adams DEPT Lathe

ORDER NO. 3631 MACHINE NO. 369

PART NAME Front Shaft PART NO. 2032

OPER. NAME Turn to size at A. OPER. NO. 1a

PIECES	P. W. RATE	AMOUNT	D. W. RATE	ELAPSED TIME	FINISH / START
236		3 83	.45	8:30	MAR 26 5 00 / MAR 26 7 28

O. K. W. B. J. FOREMAN

Fig. 50.—Specimen job time cards.

both morning and afternoon, the date of receipt, and, in a machine with various refinements, the name and address of the

owner, the classification of the matter received, and a mark indicating the person who received it. In the case of orders issued to field employees or reports received from them, such an accurate stamped record as this machine will give might avoid serious controversy in case of delay from any cause. The exact time of receipt of a report is shown or the exact time of the issuing of an order, and, if the order is not promptly obeyed, the man to whom the order is issued cannot plead the excuse that the order was not issued until after a time too late for its effective execution. Speciman job time cards made with these machines are shown in Fig. 50.

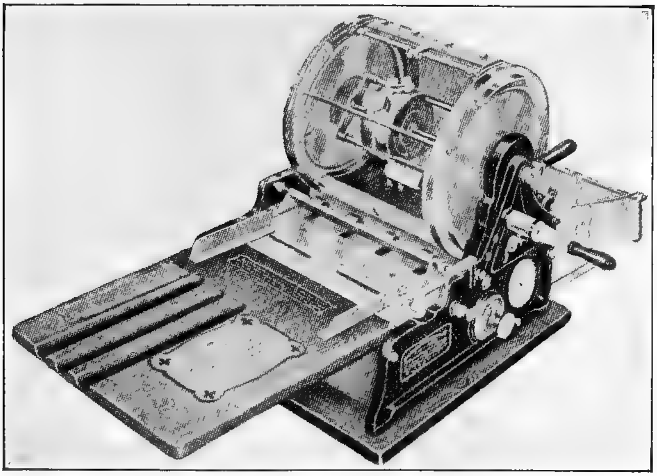


Fig. 51.—Mimeograph.

Rubber Stamps.—A full equipment of ordinary rubber stamps will be found decidedly useful in an office. Not only is much writing saved by their use, but accuracy is insured.

Mimeograph.—In its improved form the Edison mimeograph consists of a cylindrical frame for holding a waxless stencil through which mimeograph ink is forced at even pressure to the receiving sheet of paper. The stencil permits the duplication of designs, diagrams and free hand drawings on the same sheet that carries the typewriting.

There are various sizes of mimeographs. Figure 51 shows one priced at $110. This machine equipped with an automatic feed

costs $150. These machines with stands and motors for electric operation cost about $100 more. A small machine costs $45. The Mimeograph is made by the A. B. Dick Company of Chicago and New York.

The authors have used the mimeograph extensively for making report blanks, as well as for issuing orders. On any new class of work, it is generally wise to use mimeographed report blanks, for changes in the methods of doing the work and in the organization are likely to occur, and such changes frequently necessitate alterations of the report cards. A new report card can be quickly

FIG. 52.—Burroughs adding or listing machine.

designed and hundreds struck off with a mimeograph, without any delay in waiting for printers.

Adding or Listing Machines.—Where there is any considerable amount of office work, an adding machine should certainly be used. Figure 52 shows a Burroughs machine, hand-operated. A nine column machine costs from $150 to $400 depending upon the refinements and whether it is hand or electrically operated. These machines are made by the Burroughs Adding Machine Company of Detroit.

Calculating Machines.—Figure 53 shows the Comptometer made by the Felt and Tarrant Manufacturing Company of

Chicago. This machine may be used for ordinary arithmetical processes. It costs from $300 up depending upon the number of columns of keys.

A similar machine is manufactured by the Burroughs Adding

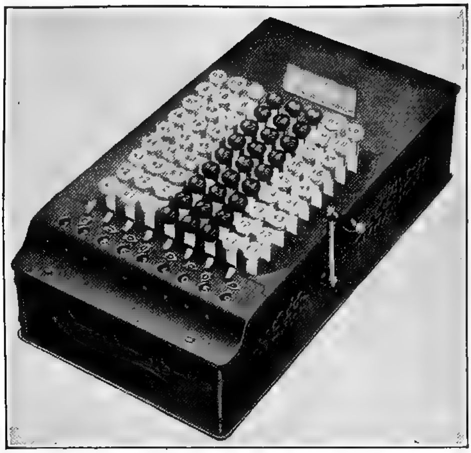


FIG. 53.—Comptometer.

Machine Company and is shown in Fig. 54. A 10-column capacity Burroughs machine costs $200.

Another make of calculating machine is shown in Fig. 55. It is the Monroe Calculating Machine. This machine works on a

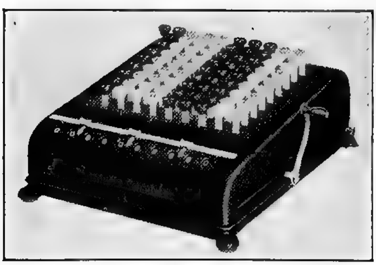


FIG. 54.—Burroughs calculator.

different principle from the machines previously described in that the selecting of numbers and carrying of tens is accomplished by direct lever and cam action instead of by springs. It is manufactured by the Monroe Calculating Machine Company of New York and sells for $300.

A calculating machine that differs from those previously described in that it has but 10 keys and a listing attachment, is

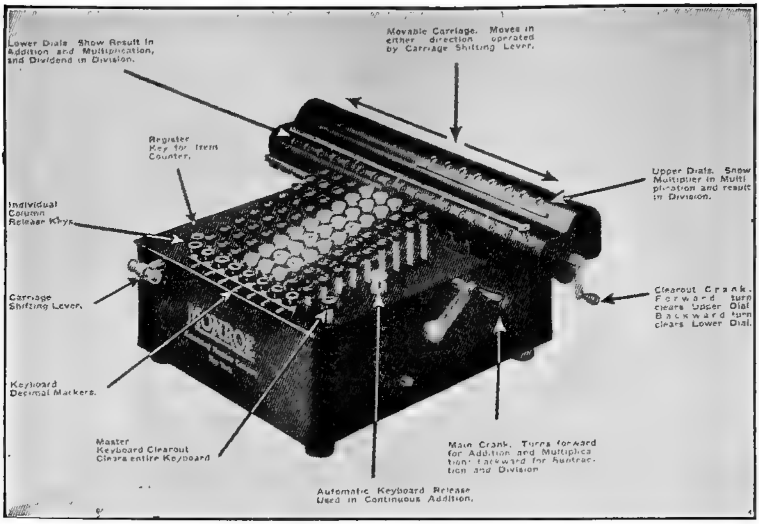


Fig. 55.—Monroe calculating machine.

Fig. 56.—The Dalton machine.

made by the Dalton Adding Machine Company of Cincinnati. This machine is illustrated by Fig. 56, and is used for adding,

subtracting, multiplying, dividing, interest figuring and numerous other mathematical calculations. Its price, regular size, is $250. This machine may also be had in various styles at a cost of from $125 to $350 and may be equipped with electric drive at a cost of $100 extra.

Complete instructions are given by the manufacturers of calculating machines, and, when once mastered, these machines will be of inestimable value.

Portable Typewriter.—A portable typewriter which may be used to great advantage in writing up field reports and work of like nature is shown in Fig. 57. This machine is manufactured by the Underwood Typewriter Company of New York and sells for $50.

FIG. 57.—Portable typewriter.

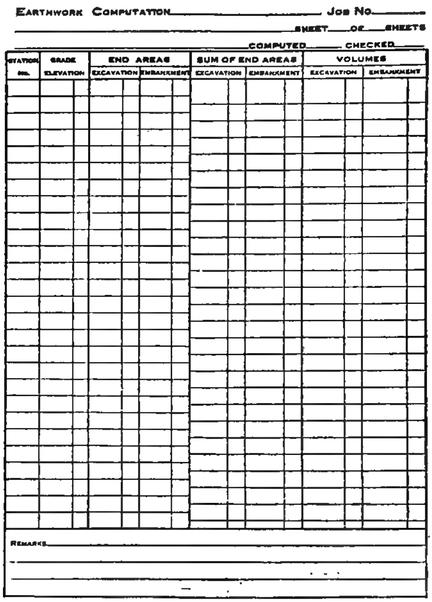
Slide Rule.—It is of course understood that the slide rule is not a multiplying machine that is accurate beyond certain limits. Within those limits—which depend on the kind and size of the rule—it is perfectly accurate. For purposes of estimating and for making ordinary designs, the slide rule gives results that are close enough. A 10-in. rule—the size most commonly used—costs $7.50. Any dealer in civil engineering instruments will furnish slide rules.

Planimeter.—The planimeter, like the slide rule, is so well known as scarcely to require mention here. For figuring the areas of irregular cross-sections, the planimeter is a great labor saver; but its absolute accuracy depends largely upon the scale to which the cross-section is plotted. The commonest error in

the use of a planimeter is the plotting of cross-sections to a small scale.

There are many styles and sizes of planimeters, ranging in price from $16 to $100. A good instrument for ordinary use can be had for $25.

Graphic Charts.—Charts may be used to great advantage for cross-section work, drawing up details, designing, estimating and for plotting records of cost and performance.


EARTHWORK COMPUTATION ____ JOB NO. ____
SHEET ____ OF ____ SHEETS
COMPUTED ____ CHECKED ____

STATION NO.	GRADE ELEVATION	END AREAS		SUM OF END AREAS		VOLUMES	
		EXCAVATION	EMBANKMENT	EXCAVATION	EMBANKMENT	EXCAVATION	EMBANKMENT

REMARKS ____

FIG. 58.—Earthwork computation sheet.

Cross-section charting paper is ordinarily divided into tenths or twentieths of an inch. and will be found of material assistance in drawing to scale the section of any excavation, fill or work of like nature.

In detail work, a ruling, divided into 20, 16, 12, 10, 8 or 4 divisions per inch may be well used for drawings, either actual size or scaled, of machine parts, patterns, forms, concrete slabs, etc.

Sheets, such as the above, may be used in designing and will provide a means to eliminate long and tedious calculations.

They may also be used in estimating and will present a rapid and accurate method which is highly recommended for wide use.

Charts of progress on work present a picture of actual performance that will show, with intelligent study, whether an operation or job is progressing according to the required schedule or is falling behind.

The methods of making charts and their applications can only be referred to here. A book covering this subject in detail however, may be had of the Codex Book Company of New York. It is called "How to Make and Use Graphic Charts" by A. C, Haskell. Sheets of ruled paper, especially designed for this work, are also furnished by this company in a wide variety of rulings.

Forms.—Miscellaneous cost and computation forms are described in Chapter IX. A standard form for earthwork computation is shown in Fig. 58. This form is one of a number furnished by the Codex Book Company of New York. The forms are made up in pads of 100 sheets each and cost $2 per pad printed on bond paper.

Order System by Means of a Card Index.—This system, which was used by a large contracting firm, was described by C. Arthur Worden in *Engineering-Contracting*, June 3, 1908, as follows:

Each order is made out in triplicate. The original, Fig. 59, is mailed to the firm or party from whom the material is ordered. At times, the list of material is too large to be put on the regular order form and in that case the words "kindly furnish us with material as per list attached to and forming a part of this order" are substituted. The list is then made in triplicate, and one copy is attached to each copy of the order.

This and the blanks shown in Figs. 60, 61 and 62 are much condensed.

The "Office and Purchase Record," Fig. 60, is retained in the Home Office, while the "Receiving Department" copy is mailed to the Field Office having that particular contract in charge.

Figure 59, as will be noted, gives the forwarder of material all information in regard to shipment, manner of rendering invoice, etc. Attached to this slip are two stubs: the first, or acknowledgment slip, is to be returned to the contractor immediately, stating probable date of shipment; the second slip is returned as soon as the order is completed, and should have attached the itemized invoice and Bill of Lading.

Order No. *2510* Date *April 25/08.*

James Goodnow, Esq.,
143 Liberty St.,
New York City.

JOHN DOE CO.
Engineers and Contractors
N. Y. City.

Please furnish us, without delay, the following material:
(a) *150 feet Monarch sash chain at 3 cents per ft.*
(b) *10 kegs 20d wire nails at $2.50 per keg.*

Send Bill of Lading and itemized invoice to us on day of shipment.
Always put order number on invoice.
No boxing or crating paid for unless specified on order.

Ship via *N. Y. C. & H. R.* F. O. B. *New York*
Ship to *John Doe Co.,*
c/o Frank Miller,
Albany, N. Y.

JOHN DOE CO.
By *C. A. Worden.*

(Detach and return to us.)

__________190__

JOHN DOE CO., New York:
We have this day completed shipment on your order No. ______, same going forward via________ R. R. Co. / Express Co.

(Detach and return to us.)

ACKNOWLEDGMENT SLIP.

__________190__

JOHN DOE CO., New York:
We acknowledge receipt of your order No.______ and will ship from ________ on________
(Give definite date of shipment.)
This order will be executed in accordance with conditions stated.

FIG. 59.—Order blank. This and the blanks shown in Figs. 60, 61 and 62 are much condensed.

Order No. *2510* Date *Apr. 25/08.*

James Goodnow, Esq.,
143 Liberty Street,
New York City.

Office and Purchase Record
JOHN DOE CO.
N. Y. City.
Freight $ *1.34* Transp't'n p'd by *J. D.*
Cartage $ *.25* Date Rec'd *4/3/08*
Express $ __ Checked by *J. D.*

(a) *150 feet Monarch sash chain at 3 cents per ft.*
(b) *10 kegs 20d wire nails at $250 per keg.*

Charge *a* to *Doors and Windows*
" *b* to *Timber*
" __ to __

Ship via *N. Y. C. & H. R.* F. O. B. *New York*
Ship to *John Doe Co.*
c/o Frank Miller,
Albany, N Y.

Order completed *4/1/08*
Bill Checked by *O. K.*
Date *4/5/08*
Voucher No. *374*

FIG. 60.—Office and purchase record blank.

The "Office & Purchase Record," Fig. 60, is printed on a light weight card, suitable for filing in a small vertical file. The order number, date, and name of party to whom order is given, appear in the extreme upper left hand corner, thus giving easy access to the record in the file when desired. In the upper right hand corner, blank spaces are given in which are to be noted the amount of freight, express or cartage paid by the Field Office, date of delivery, name of party paying transportation charges and party checking the material upon receipt. This information will be noted on the Record as soon as the receiving slip is received from the Field Office, and will be needed in checking

Order No. *2510* Date *Apr. 25/08*

James Goodnow, Esq.,
143 Liberty Street,
New York City.

RECEIVING DEPARTMENT
JOHN DOE CO.
N. Y. City.
Freight *$1.34* Transp't'n p'd by *J. D.*
Cartage *$ .25* Date Rec'd *4/3/08*
Express $ Checked by *J. D.*

(*a*) *150 feet Monarch sash chain at 3 cents per ft.*
(*b*) *10 kegs 20d wire nails at $2.50 per keg.*

Charge *a* to *Doors and windows*
" *b* to *Timber*
" to

Ship via *N. Y. C. & H. R.* F. O. B. *New York*
Ship to *John Doe Co.,*
c/o Frank Miller,
Albany, N. Y.

Check up all goods as soon as received; and return this slip to Home Office at once, using back of same for detailed statement, if necessary.

Fig. 61.—Receiving department order.

the invoice. In the lower right hand corner is given the item in the cost data to which material covered by order is to be charged, date of completed shipment, name of party checking invoice, date of checking and the voucher number. The voucher is very seldom used for information, as the Office and Purchase Record will show all that is ordinarily required.

The "cost data" to which reference is made may be described as follows:

A book is provided in which each contract is subdivided into various items, such as excavation, concrete forms, concrete, timber work, doors and windows, etc. Labor and material are charged under these headings in separate columns, so that, at any time, the cost to date of ether or both may be ascertained, and at the completion of the work the contractor may see not only

the total profit or loss on the job, but also how the actual costs of the various items compare with the estimated costs.

The "Receiving Department" copy, Fig. 61, is used on the job in checking material when received. In all cases the freight, express or cartage charges, if any, should appear on this slip before mailing to Home Office. This copy when received at Home Office is attached to the Office and Purchase Record bearing same number, and filed until the invoice has been checked, when it is attached to same, thus giving a complete record of the transaction in the voucher.

The order file should be provided with three guide cards, thus:

Order No. *2510*	Placed with *James Goodnow*	Date *3/25/08.*
		Completed *4/1/08.*
Cont. No. *752*	Tel. No. *2900 John*	Address *143 Liberty St., N. Y. C.*
Order by *C. A. W.*	Correspondent *Mr. Goodnow*	
Material *Sash Cord—Nails*		
Followed up | *3/28 phone* | *3/30 letter* | | | |		
Date acknowledgement slip *3/28*	Freight	Express
Shipment asked for *immediate shipment from stock*		
" promised *3/29*		

Complete or Partial	A	B	C	D	E	
Date of Shipment	*4/1/08*					
" Ship'g Papers	*4/1/08*					
Due at Destination	*4/3/08*					
Request for Tracer	✓					
Material Received	*4/3/08*					

Form 5, see other side for Memorandum.

FIG. 62.—Card system for follow up.

1. Marked "Ordered," behind which the Office and Purchase Record should be filed as soon as made out.

2. Marked "Received." When the "Receiving Department" copy is returned, it should be attached to the Office and Purchase Record and filed behind this guide card, preparatory to checking the invoice.

3. Marked "Checked." This is a final file for the Office and Purchase Record as soon as invoice has been checked.

In all cases cards should be filed numerically.

Section 1 of this file can easily be converted into a follow-up file by putting in guide cards of a different color from the one marked "ordered," and numbered from 1 to 31. Order No. 2,510, say, was promised on the 29th. The Office and Purchase

Record bearing this number is filed under the 29th and the order clerk in going over his records on that date will find this card and follow up the shipment.

Figure 62 shows a card system for following up, which, while more complicated, gives far more satisfactory results. This card may be filed in a "daily reminder" file under date of promised shipment, and all information can be noted thereon instead of on the Office and Purchase Record.

This card explains itself.

CHAPTER IX

MISCELLANEOUS COST REPORT BLANKS, AND SYSTEMS OF COST KEEPING

With the sample cost report cards given in the fore part of this chapter will be found reprints of a number of articles describing various cost keeping systems.

Construction Service Co.
Contract # 40
Steam Shovel Record.

Location South Cut Weather Clear Date June 1-1909

No.	Work.	Work Done.	Reg. Hours.	Reg. Rate.	Extra Hours.	Extra Rate.	Total.	Total Amts.	Unit Costs.
1	Engineer		10	.30			3.00		.006
1	Craneman		10	.30			3.00		.006
1	Fireman		10	.20			2.00		.004
1	Pit Foreman		10	.40			4.00		.008
3	Pitmen		10	.15			4.50		.009
								16.50	
	Blacksmith								
	Incidental								
	Water Supply								
	Fuel "	1 1/3 tons coal at $3.00 delivered						4.00	.008
	Total								

Name & No. of Shovel Vulcan Cap. of Bucket 1 c.y.
Width of Breast Ft. above track at which mat'l dumped
No. of Moves Total feet moved up.
Delays, From to Cause
Haul 1000 ft.

Coal used Oil Waste
Repairs & supplies needed
Total cars or carts loaded Cap. of car or cart 3 c.y.

FIG. 63.—Daily report, steam shovel.

As previously explained, it is rare that a report card for any given class of work will exactly meet the requirements of all contractors doing that class of work. Hence, the report cards that follow are intended to serve merely as guides. Regarding the cost-keeping systems, however, there are many features

that may be profitably adopted in their entirety by other contractors. Hence we have deemed it wise not to condense the original articles.

A Cost keeping System and Its Application to Street Paving.[1]—The accompanying illustrations show the set of blanks used by Kaumeier Bros., general contractors, Port Huron, Mich., for the purpose of keeping records of their paving work.

Construction Service Co.
Contract #
Dump Train Record.

Location Weather Date

No. & Weight of Engine

Runner Brakeman

Trip	Left Shovel	Left Dump	Cars	Trip	Left Shovel	Left Dump	Cars

Engine inspected by Date

Repairs needed

Condition of engine Cars Track

Length of haul

Coal used Oil Waste Other supplies.

No. of Cars used Cap. of car Aver. wt. of empty car.

B-4

FIG. 64.—Daily report, dump train.

Figure 91 shows a blank used for a daily curbing report. This work is always in charge of a separate foreman and consequently a separate report is made. Figure 92 shows the blank used for a daily time sheet. Stiff folders, with a loose binder so that the cover folds back straight, are used to hold these blanks. The blanks are taken out by the foreman onto the work, and whenever a man is changed from one class of work to another the

[1] *Engineering-Contracting*, June 10, 1908.

[2] Figs. 91 to 94 on pages 323 to 326.

foremen simply mark the time under its proper classification, and when the blank is turned in at night the number of hours worked is put on in ink, as shown in columns 1 and 2 of Fig. 92. It will be noticed in Fig. 92 that employe No. 1 worked from 7 to 9 at plowing, from 9 to 11 in rolling subgrade and so on. It takes the foreman but a second to note the time, as he always has his folder handy. All other clerical work is done at the office.

Construction Service Co.
Contract #
Blasting.

Gang No. Location. Weather Date

No.	Work.	Work Done	Reg. Hours.	Reg. Rate.	Extra Hours.	Extra Rate.	Total.	Total Amts.	Unit Costs.
	Foreman.								
	Loaders.								
	Clean'g Holes.								
	Carry'g Powd.								
	Cleaning Up.								
	Totals								

No. Holes loaded & depth — Kind of Powder — % & make & amount

No. of Holes sprung

Exploders — Kind & No. used

Material needed and when

Supplies " " "

Kind of Rock — Spacing of Holes

-G-1

FIG. 65.—Daily report, blasting.

Figure 93 shows the blank used for a daily report. This daily report is a recapitulation of all work performed during the day, as well as of all material received. This report must be filled out by the foreman each night as to the amount of work performed and material received. All other work, such as cost data, is figured out in the office. Under this method it can be observed each day as to whether the foreman is getting efficient

work out of his men or not, and is a good way of demonstrating to him where they are falling behind and where an improvement can be made.

The card shown in Fig. 94 is a teaming card, and one of them is given to each teamster. The letter "O" is used to note the time of arrival of the letter "X" the time of departure. The letter "S" is used to indicate that the team drew a load of stone; the letter "G" indicates a load of gravel and the letters "Sd"

Construction Service Co.
Contract #
Channeling

Location   Weather   Date

No.	Work	Work done	Reg. Hours.	Reg. Rate.	Extra Hours.	Extra Rate.	Total.	Total Amts.	Unit Costs.
	Channeler								
	Helper								
	Fireman								
	Water Supply								
	Fuel "								
	B'smith								
	Total								

Length of cut   Depth   sq. ft.
"   "   "   "   "
Kind of Rock   Total sq. ft.
Condition of Track   Condition of machine
Delays from   to   cause

Coal used   Oil   Waste   Other supplies
Repairs & supplies needed

Fig. 66.—Daily report, channeling.

a load of sand. In the card shown in Fig. 94 it will be observed that the team arrived at 7:10 and departed at 7:16, arriving back on the second trip at 8:04 and departing at 8:12. This card should be left with the teamster so that he can call the checker's attention to it on each trip. If this is not done the checker is apt to mark the card wrong, but with the teamster carrying the card there will be no trouble about its being

marked each trip, for he will naturally be anxious to get in his right number of trips.

Inspector's Daily Report on Paving.—In *Engineering News*, April 2, 1908, M. G. Hall has described the report shown in Fig. 95.[1] Each inspector was required to record the number of men and their occupations once an hour during the day.

Construction Service Co.
Contract #
Drill Gang Record.

Cut No. Location Weather Date

No.	Work.	Work done	Reg. Hours	Reg. Rate	Extra Hours	Extra Rate	Total	Total Am'ts.		Unit Costs
	Foreman.									
	Runners.									
	Helpers.									
	Mucking.									
	Nippers									
	Pipe Fitting.									
	Blacksmith.									
	Waterboy.									
	Watchman.									
	Power Sta.									
	Totals.									

Oil consumed	Make and size of machines
Coal "	
Other supplies	Dia. of starting bits
Mat'l needed & when	
Kind of rock	Spacing of Holes
Remarks	

B-1

FIG. 67.—Daily report, rock drilling.

A Flexible Cost-keeping System and Its Application to Building Construction.[2]—Sam. W. Emerson, of Cleveland, has contributed to the science of cost keeping a description of an ingenious system which has great flexibility and can be applied to many classes of work. In some respects the system lacks completeness of detail, but when time is lacking to devise special blanks it has great usefulness. Mr. Emerson's description is given below:

[1] See page 327.

[2] *Engineering-Contracting*, *June* 13, 1906.

The work is all done by the timekeeper, who in addition to his regular time-book carries a small note-book. An engineer's transit-book answer admirably, or books may be made up with ruling similar to the illustration. A number of columns are ruled on the right-hand page, one for each rate of wages paid on the job and one for the totals.

Construction Service Co.
Contract #
Blacksmith Record.

Location Weather Date

Work	Work Done.	Reg. Hours.	Reg. Rate.	Extra Hours	Extra Rate.	Total.	Total Amts.	
Drill bits								
Channeler "								
Repair Drills								
" Stm Shovel								
" donkey & cars								
" channeler								
Horses & Carts								
Water Supply								
Conc. Mixer								
" Plant								
Miscel.								
Total								

Coal on hand Quality.

6-4

FIG. 68.—Daily report, blacksmith.

Figure 96[1] shows the system applied to building construction, the cost of each class of work being kept separately on each building. On the left-hand page is given the location and class of work.

The timekeeper making his rounds in the morning, notes in the column corresponding to the proper date the number of men doing each class of work. Four trips are made over the job each day, on each of which any changes in the distribution of men are noted. On the last trip the total number of hours worked on each class of work is put down in the proper column.

[1] See page 328.

The small figures in the upper and lower left-hand corners of the small square indicate the number of men working in the morning and afternoon. The large figures give the total number of hours worked, which, multiplied by the rate at the head of the column, gives the cost in dollars and cents in the right-hand (total) column.

Construction Service Co.
Contract #
Derrick Record

Location Weather Date

No.	Work.	Reg. Hours.	Reg. Rate.	Extra Hours.	Extra Rate.	Total.	Total Amts.	Work Done.	Unit Costs.
	Enginemen								
	Tagman.								
	Load Buck't								
	Dump'g "								
	Setting Up Derrick.								
	Taking Down Derrick.								
	Placing Anchors.								
	Foreman.								
	Total								

Guy or peg-leg derrick. Height Length of boom

Kind of bucket or skip Capacity

Kind of material moved Quantity

Coal used Oil Waste

Other supplies used

A-7

FIG. 69.—Daily report, derrick.

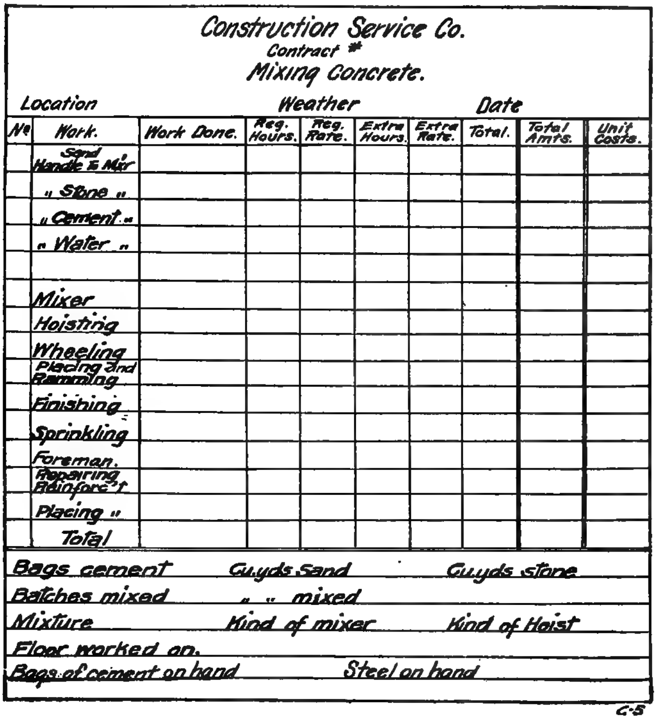
The sample page shows that on April 10, eight bricklayers at 60 cts. one foreman at 70 cts. and 10 laborers at 22½ cts. each worked 8 hr. on building *A*.

On the same building 10 carpenters at 30 cts. and one foreman at 35 cts. worked 9 hr., four of them putting in half a day setting window frames while the balance of the work consisted in laying roof sheeting.

No concrete was placed on this date, but the cost of hauling gravel, moving the mixer and bailing sacks is given. The num-

ber of loads of gravel hauled is stated and if any concrete had been mixed the number of sacks of cement used would have been shown.

From the above it will be seen how easy it is with this system to learn the cost of special items, such as moving a mixer, setting up a derrick or repairing a breakdown, etc., which would ordinarily be merged into some general account.



Construction Service Co.
Contract #
Mixing Concrete.

Location Weather Date

No	Work.	Work Done.	Reg. Hours.	Reg. Rate.	Extra Hours.	Extra Rate.	Total.	Total Amts.	Unit Costs.
	Handle Sand & Mix								
	" Stone "								
	" Cement "								
	" Water "								
	Mixer								
	Hoisting								
	Wheeling								
	Placing and Ramming								
	Finishing								
	Sprinkling								
	Foreman.								
	Repairing Reinforc't								
	Placing "								
	Total								

Bags cement Cu. yds. Sand Cu. yds. stone
Batches mixed " " mixed
Mixture Kind of mixer Kind of Hoist
Floor worked on.
Bags of cement on hand Steel on hand

C-5

FIG. 70.—Daily report, concrete mixing.

At the end of each week the distribution book was checked with the pay roll. The difference between them seldom exceeded a dollar or two on pay rolls of $1,000 to $1,500, and even this error could have been avoided by checking with the time-book every day.

To get the time of changes in the distribution of men, made during his absence, the timekeeper depends on the foremen or on the men themselves. Whenever convenient to figure progress,

estimates should be prepared each week and unit costs determined.

Weekly estimates are easily made by anyone who can read drawings, for brick work, laying roof sheeting, siding and earthwork. Daily estimates can be made with even less trouble for pile driving, making ties, laying pipe, curbing, pavements, etc., and any work which progresses in a straight line. Concrete can

Construction Service Co.
Contract #
Pipe Laying

Location   Weather   Date

No.	Work.	Reg. Hours.	Reg Rate.	Extra Hours.	Extra Rate.	Total.	Total Amts.	Work Done.	Unit Costs.
	Excav. Trench								
	Digging bell holes								
	Sheeting & Bracing								
	Laying Pipe								
	Handling & Pouring Lead								
	Calking								
	Backfilling								
	Ramming								
	Distributing Materials								
	Miscel.								
	Foreman.								
	Total								

Lumber used

Pipe (no. of lengths)   Laid from ⊙   to ⊙
Valves   Hydrants
Lead   Yarn
Special Materials
Miscellaneous

A-8

FIG. 71.—Daily report, laying cast-iron water pipe.

always be roughly estimated from the number of sacks of cement used.

On large jobs, where material is handled in buckets by derricks or cableway or in cars, it pays to have a boy count the loads, and his record should show the amount handled each half hour as well as the total for the day.

For the office records a loose-leaf cost ledger should be used. The loose-leaf ledger has many advantages over bound books,

one of which is that if an improvement in the arrangement or classification presents itself, the change can be made at once, with at worst no more than copying a few pages. And it is

No.	Classification	Hours	Rate	Extra Hours	Extra Rate	Extra Pay	Total Pay	Total Work Done	Unit Cost
	Loading Bucket								
	Signalman								
	Hooking on Bucket								
	Dumping Bucket								
	Driving Sheeting								
	Bracing								
	Chuting Mat. to Cars								
	Engineman								
	Fireman								
	Waterboy								
	Foreman								
	Total								

Construction Service Co.

Contract No. Trenching by Cableway

Date Foreman's Daily Report

Material	Amount used today	Amount on Hand	Amount Needed	When Needed
Coal				
Oil				
Waste				

	Rush following material, previously ordered
	Remarks
	Weather

B-10

FIG. 72.—Daily report, trenching with cableway.

only by making changes and adopting improvements as rapidly as their merit is demonstrated that a first-class system for any particular business can be obtained.

It will simplify the work greatly to have special sheets made up for this ledger wider than can usually be found in stock, say 15 in. or 18 in. wide and having a large number of vertical columns.

No.	Classification	Hours	Rate	Extra Hours	Extra Rate	Extra Pay	Total Pay	Total Work done	Unit Cost
	Pavers								
	Loading barrow								
	Wheeling "								
	Spreading Sand Cushion								
	Ramming								
	Trimming								
	Load'g Sand & Cement								
	Loading Brick								
	Hauling Sand & Cement								
	" Brick								
	Grouting								
	Foreman								
	Total								

Construction Service Co.

Contract No. Brick Pavement

Date Foreman's Daily Report.

Material	Amount used today	Amount on Hand	Amount Needed	When Needed
Brick				
Sand				
Cement				
Gravel				

Rush following material previously ordered

Remarks

Weather

C-12

FIG. 73.—Daily report, brick paving.

The use of this ledger is shown in Fig. 97.[1] All charges are entered under the proper heading and the totals can be obtained at any time by merely adding up the columns.

[1]See page 328.

A separate sheet is used for each class of work at each point, the cost, of which is wanted independently of the rest of the job. Thus for a bridge substructure job consisting of three piers

No.	Classification	Hours	Rate	Extra Hours	Extra Rate	Extra Pay	Total Pay	Total Work done	Unit Cost
	Excavation								
	Loading								
	Cinder fill								
	Staking & Setting forms								
	Mix. & Plac. Concrete								
	" & " Finish								
	Troweling								
	Waterboy								
	Hauling Mat. to Job								
	" " from "								
	Moving Plant								
	Foreman								
	Totals								

Construction Service Co.

Contract No. Cement Walk.

Date Foreman's Daily Report

Material	Amount used to-day	Amount on Hand	Amount Needed	When Needed
Cement				
Sand				
Gravel or Stone				
Cinders				
Lumber				

Depth of Excavation	Rush following material previously ordered
Width of Walk	
Cinder fill from ◦ to ◦	
Concrete Placed Mix.	
Finish Placed Mix.	Remarks.
Finished Walk from ◦ to ◦	
Length of Haul	
	Weather

C-9

FIG. 74.—Daily report, cement walk.

and two abutments, five pages would be used to cover the concrete work, one sheet for each foundation.

The cost of the excavation and pile driving would be kept in the same way and from a comparison of these sheets valuable

data would be obtained as to the efficiency of foremen and methods.

In order to show the cost of work as it progresses, only

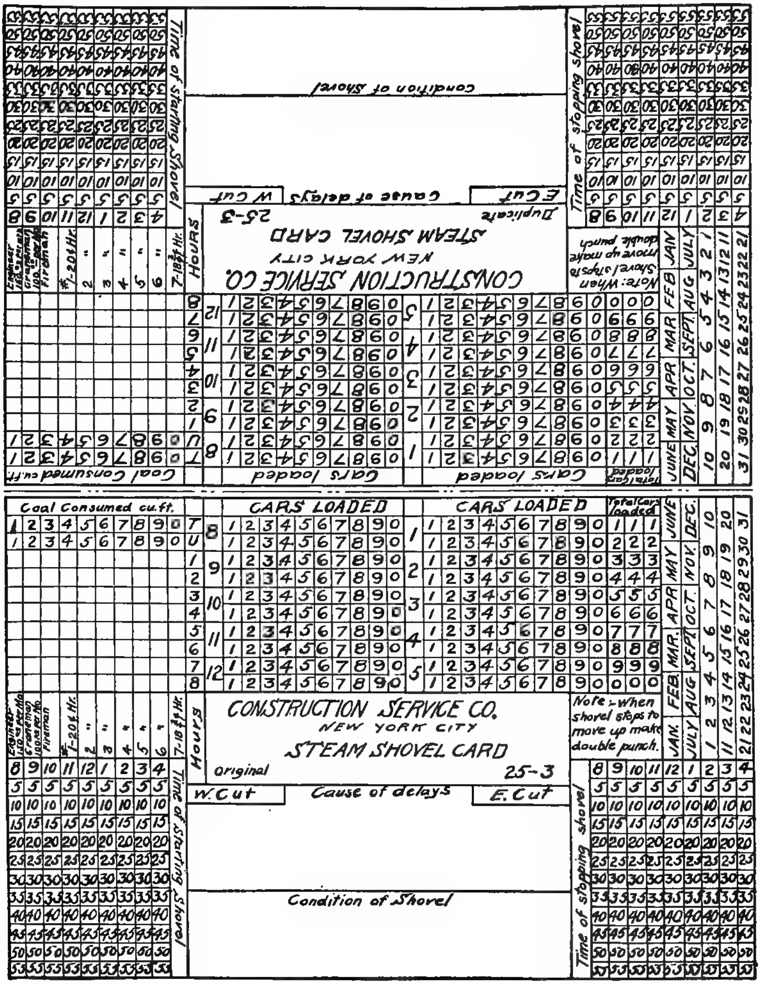


FIG. 75.—Duplicate punch card, steam shovel.

materials used, not those on hand should be charged in the ledger.

To accomplish this, materials are charged to suspense accounts as received, the charge being transferred to the ledger

account as the material is used. To the suspense account should also be charged the cost of unloading and storing the materials.

To illustrate: on a job where cement costs $1.40 per barrel, unloading from the cars 4 cts. by contract, and the cost of cement sheds, storing, loss of sacks, etc., is estimated at 7 cts., the cost of the cement sheds and all labor of unloading and storing is charged to the cement account. The cement as used is then charged to the work at $1.51 and credited to the cement account at the same rate.

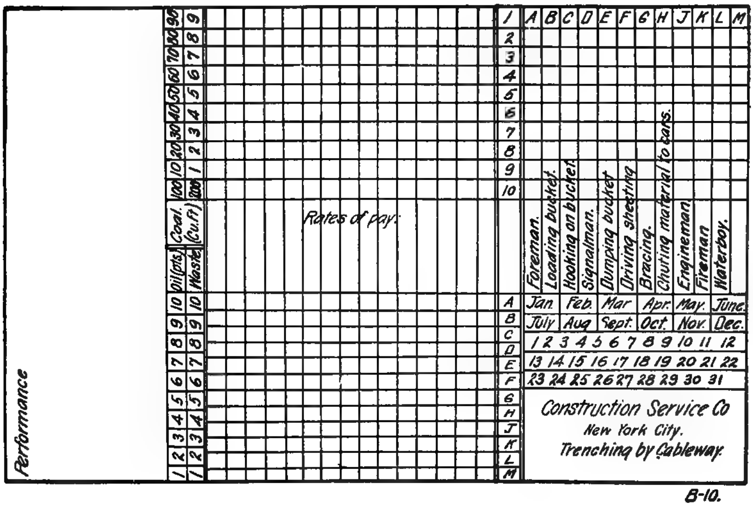


FIG. 76.—Punch card, trenching with cableway.

Other materials are treated in the same way, and at the end of the job any small errors in the estimated cost of unloading and storing can be distributed.

Credits may be shown on the ledger when necessary by using red ink.

On the completion of the job the valuable data contained in the ledger should be worked up into brief tables and filed away on cards for convenience of reference, while the ledger sheets themselves are taken from the holder and stored away in a transfer binder.

The habit of using a card file should be cultivated as it is

by far the most convenient method of filing costs records, quotations on machinery and materials, addresses of foremen and one hundred and one other things which will suggest themselves.

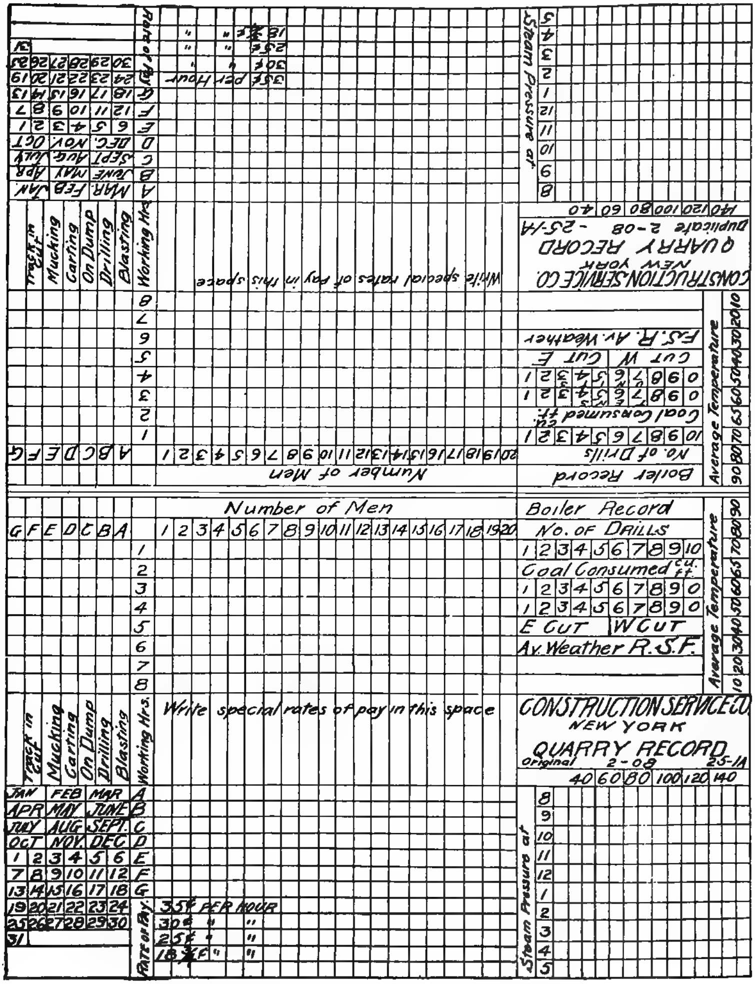


FIG. 77.—Duplicate punch card, quarrying.

In the writer's experience the cost ledger has always been kept on the job, under the direction of the superintendent. where it is to be kept at the general office, report blanks should

be used ruled like the distribution book. On to one of these the record could be copied from the distribution book and mailed to the office every evening.

From the daily reports containing an exact statement of cost and at least an approximate estimate of the work accomplished the office could keep in pretty close touch with the work.

A Cost-keeping System and Its Application to Sewer Work.[1]—The system of collecting cost data herein explained is that used by the Moore-Mansfield Construction Company and the Mans-

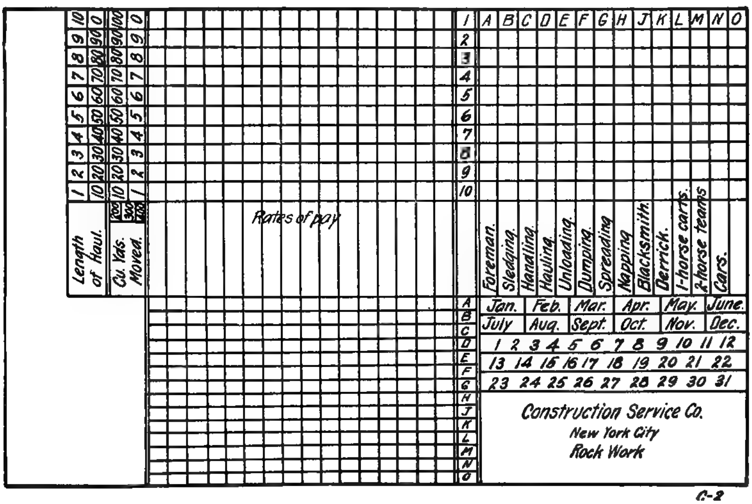


FIG. 78.—Punch card, handling crushed rock.

field Engineering Company, associated companies, maintaining an engineering designing and general contracting office at Indianapolis, Indiana. The character of the work done by them covers almost the entire field of engineering and architectural construction and it has been the effort of their Mr. Moore, who gives his time very largely to the estimating and cost record department of the organizations, to prepare a system which may be used uniformly through their work and which may be used for the different character of the work done, with only minor changes and modifications for each job.

The essential and fundamental feature of the system depends

[1] *Engineering-Contracting,* Jan. 13, 1909.

upon the form of the time sheet used (see Fig. 98, front view of time sheet, and Fig. 99, back view).[1] The time sheet is folded when in use by the timekeeper and carried in a cover, making the

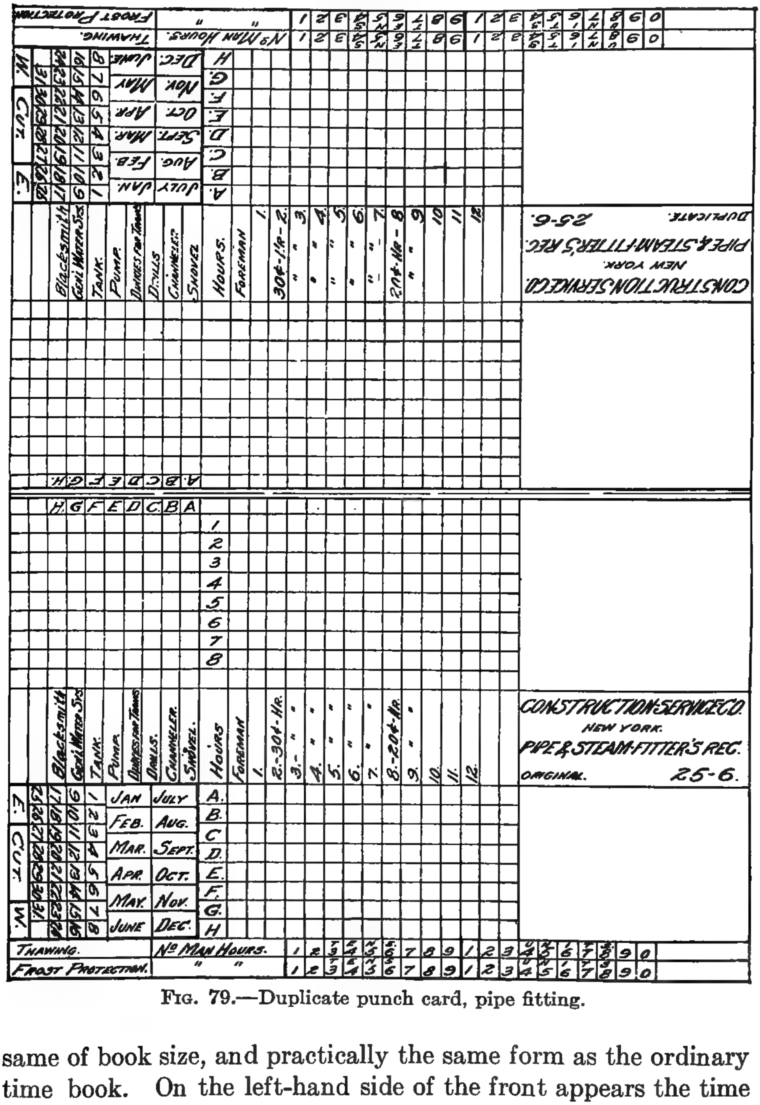


FIG. 79.—Duplicate punch card, pipe fitting.

same of book size, and practically the same form as the ordinary time book. On the left-hand side of the front appears the time sheet in the usual form. This time sheet is arranged so that it may be used for a gang reporting time weekly, and is also used

[1] See pages 330 and 331.

where the time sheet is turned in each day, in which latter case the lines under the column dates are ignored and the time placed in the total hour column. On the left-hand side appears first

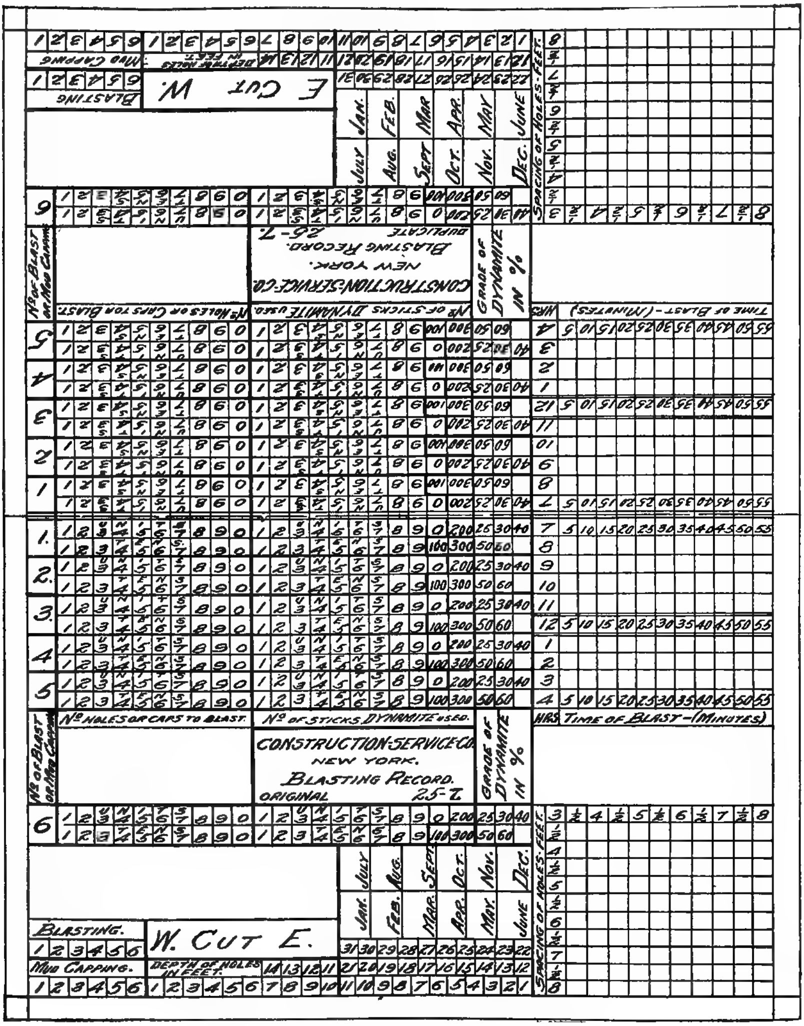


FIG. 80.—Duplicate punch card, blasting.

the timekeeper's check column. The instructions to the timekeeper on the back of the sheet (Fig. 99) are probably sufficiently clear, although it might be added that where the time sheet is

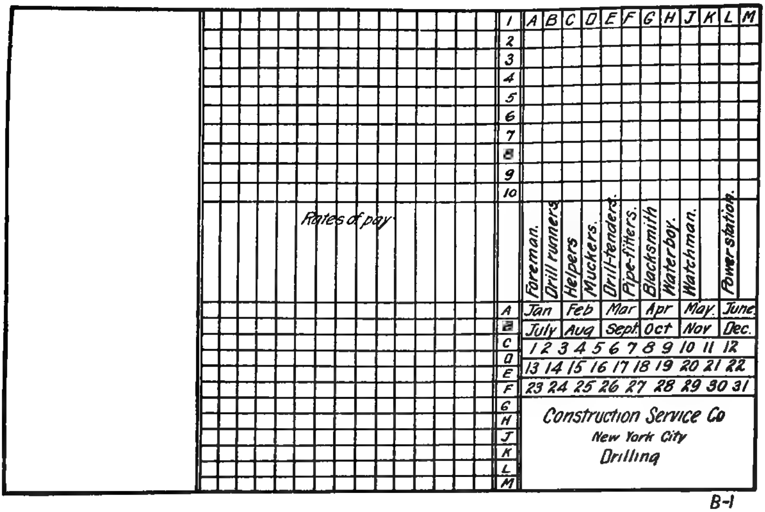


FIG. 81.—Punch card, rock drilling.

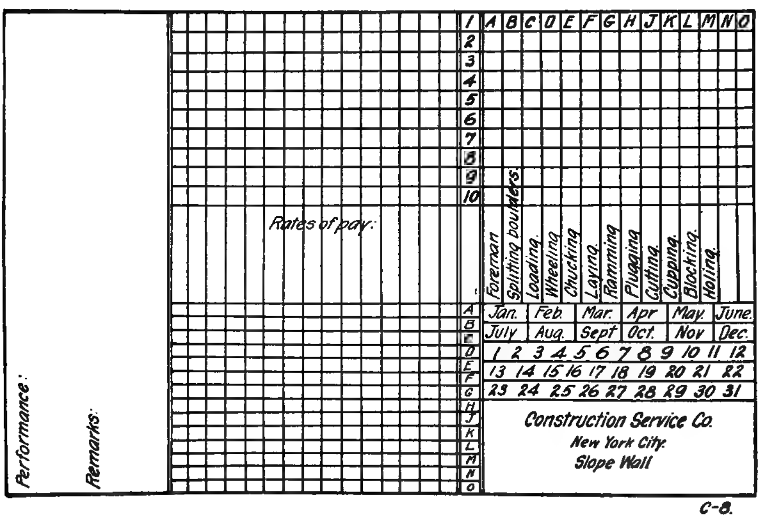


FIG. 82.—Punch card, slope wall.

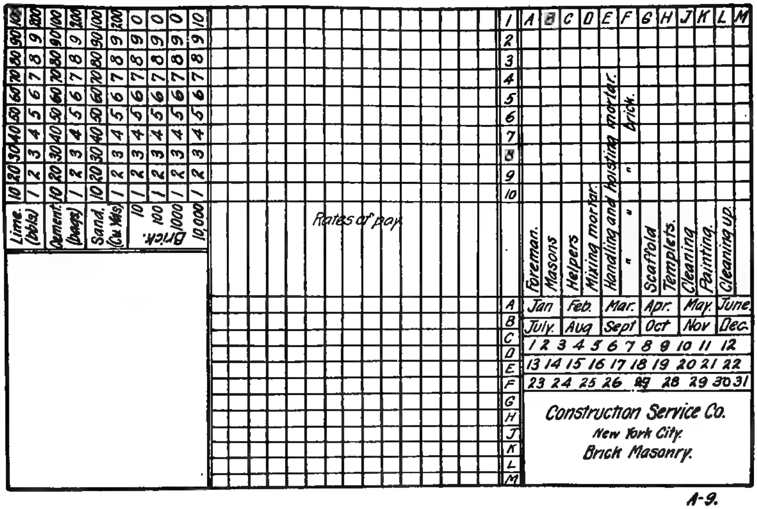


FIG. 83.—Punch card, brick masonry.

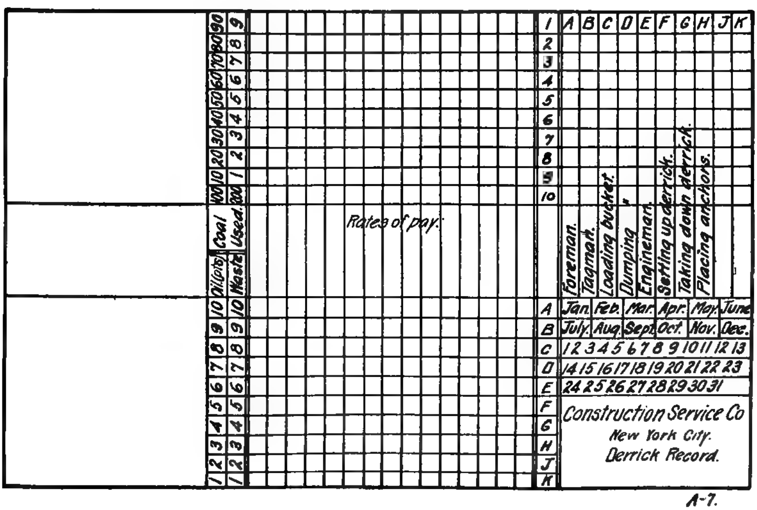


FIG. 84.—Punch card, derrick.

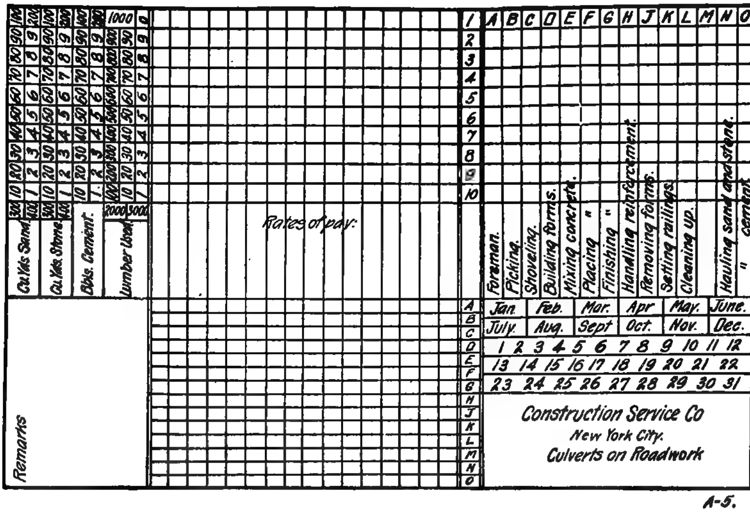


FIG. 85.—Punch card, road culverts.

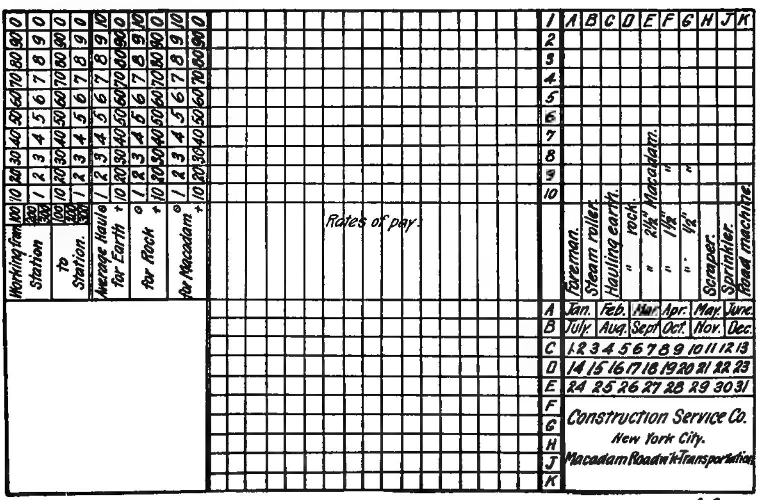


FIG. 86.—Punch card, roadwork.

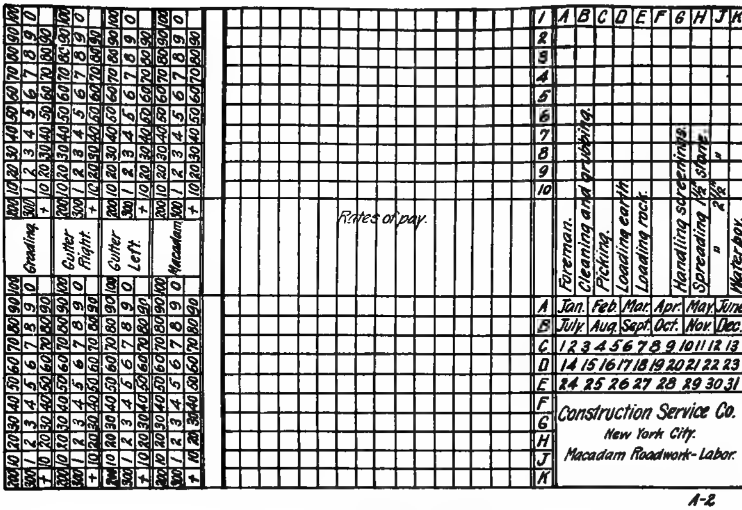


FIG. 87.—Punch card, macadam.

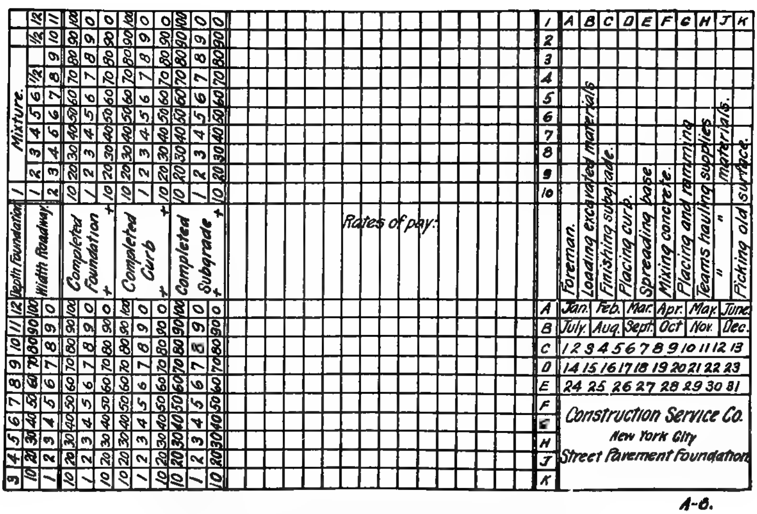


FIG. 88.—Punch card, street pavement base.

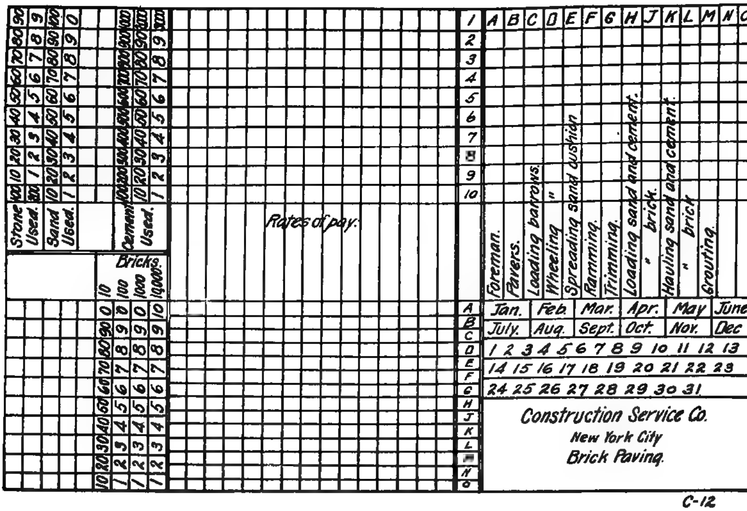


Fig. 89.—Punch card, brick paving.

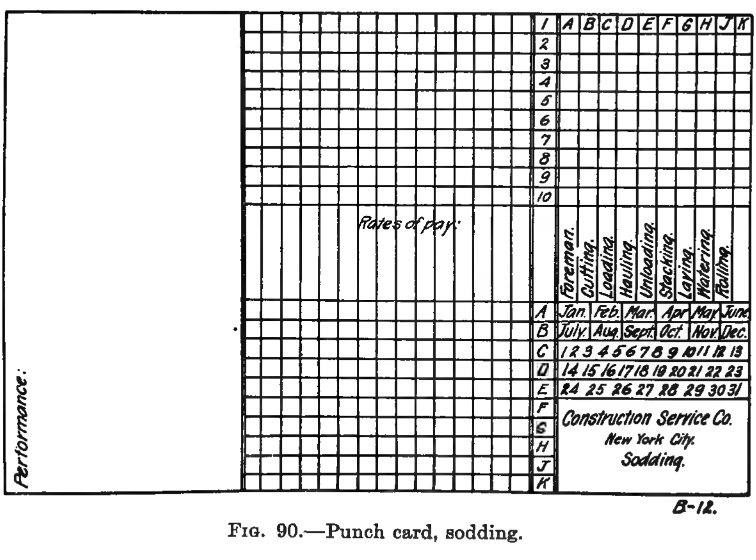


Fig. 90.—Punch card, sodding.

used as a weekly report, as is generally the case, where the gang is small or where the work is unimportant, the time is checked and divided by means of the four squares under each data and opposite each name, each square thus representing one-fourth

City of________________ Street________________ Date________________190__

NO. OF EMPLOYEE		Total Hours
Digging Trench		
Filling & Tamping foundation		
Setting Stone Curbing		
Setting Form for Cement Curbing		
Constructing Cement Curbing		
Setting Forms for Curb & Gutter		
Constructing Curb & Gutter		
Removing Forms		
Constructing Headers		
Hauling and Unloading Cement		
Sundry Teaming and Labor		
Backing up Curbing		
Total Hours		
Rate Per Hour		

CEMENT

No. Sacks on hand A. M.________________

No. Sacks received________________

No. Sacks used________________

No. Sacks on hand at night________________

No. Empty sacks returned________________

GRAVEL, STONE AND SAND.

No. Loads concrete Gravel received________________

No. Loads concrete Stone received________________

No. Loads concrete Sand received________________

No. Loads filling Gravel received________________

No. Loads filling Sand received________________

No. Loads concrete Gravel used________________

No. Loads concrete Stone used________________

No. Loads concrete Sand used________________

AMOUNT OF WORK PERFORMED

No. Feet of Trench, complete________________

No. Feet of Trench for Cement Curb and Gutter, complete________________

No. Feet of Form set________________

No. Feet of Stone Curbing set________________

No. Feet of Cement Curbing laid________________

No. Feet of Cement Curb and Gutter laid________________

No. Feet of Cement Headers laid________________

________________Foreman.

All remarks must appear on the other side.

FIG. 91.—Curb report (see p. 301).

of a day. In the case of the time sheet as illustrated, the distributions shown are for a sewer job and the particular distributions required are shown printed in by means of a rubber stamp. Each distribution thereby for this job shows a particular

key letter although the same letter may not mean the same thing on any two jobs, but reference is made to the rubber stamp heading on each contract to determine the meaning of such letter.

In the case of the daily report of a job in the timekeeper's

Street __________ Date __________ 190__ City __________

	No. of Employee	1	2	3	27	28	29	30	31	32	33	Total Hours
GRADING	Plowing	7-9 2										
	Excavating											
	Rolling Subgrade	9-11 2										
CONCRETE BASE	Hauling & Loading Concrete Gravel	11-12 1										
	Hauling & Loading Concrete Stone											
	Hauling & Loading Concrete Sand											
	Laying Concrete											
	Hauling & Unloading Cement											
BRICK	Hauling & Unloading	1-6 5										
	Laying Brick		7-8 1									
	Making Cushion		8-12 4									
	Hauling & Loading Cushion Sand											
	Culling Brick		1-3 2									
	Rolling Brick											
FILLER	Putting in Filler		3-6 3									
	Hauling & Loading Filler Sand											
	Putting in Expansion Joints											
SEWERAGE	Putting in Sewers & Inlets											
	Putting in Catch Basins											
	Putting in Manholes											
SAND	Screening Sand											
CURBING	Hauling & Loading Gravel or Stone											
	Hauling & Loading Sand											
	Hauling and Unloading Cement											
SUNDRIES	Hauling & Loading filling Gravel or Sand											
	Cleaning up											
	General											
MACADAM	Rolling Stone											
	Spreading Stone											
	Total Hours	10	10									
	Rate Per Hour	35	20									

All remarks must appear on the other side.

__________ Foreman

FIG. 92.—Daily time report, paving (see p. 301).

check column, each principal column under the "Dates" is counted as 2 hr. or each single column is counted as 1 hr. Each small square opposite each name in such column indicates a 30 min. check. By this means, automatically a man's time is checked by 30-min. intervals extending over a 14-hr. day.

using a checking system of this sort, it is not necessary to write the letter indicating the distribution in each square. Suppose that, in the first square in the first column, a man is checked in at 7:00 as working on excavation, distribution A; no further

City of ________________ *Street* ________________ ________________ *190*

Weather Condition A. M. ________________ *P. M.* ________________

CONCRETE BASE (Cement)	Amount		No. Hrs.	Rate	TOTAL	Cost per M	Cost per Sq. Yd.	Cost per Cub. Yd.	Cost per Lin. Ft.
No. Sacks cement on hand A. M.									
No. Sacks cement received									
No. Sacks cement used									
No. Sacks cem't on hand at night									
No. Empty sacks returned									
No. Sq. yards concrete laid									
GRAVEL, STONE & SAND									
No. Cub. yards concrete gravel received									
No. Cub. yards concrete stone received									
No. Cub. yards concrete sand received									
No. Cub. yards filling gravel received									
No. Cub. yards cushion sand received									
No. Cub. yards Grouting sand received									
GRADING									
No. Loads of Dirt hauled									
No. Loads of cobble stone hauled									
No. Loads of rubbish hauled									
BRICK									
No. Brick unloaded									
No. Sq. yards laid.									
FILLER									
No. Sq. yards laid									
No. Sacks cement received									
No. Sacks cement used									
No. Sacks cem't on hand at night									
SEWERS									
No. Feet Tile received									
No. Common Brick received									
No. Feet Tile laid									
No. Inlets set									
No. Catch Basins, completed									
No. Manholes, completed									
SUNDRY ITEMS									
Amount of Coal received									
Tools & Supplies received									
Name & No. cars unloaded									
Overhaul No. loads from and to (State exact points.)									

Submitted ________________ Foreman.

All remarks must appear on the other side.

FIG. 93.—Foreman's daily report, paving (see p. 302).

letters or checks are made until this man changes the nature of his occupation, which we will assume is done at 10:30, in which case a check is made in the bottom square under the 10-hr. column. Suppose, in this case, the man changes his work to

distribution *C*, indicating back fill. This distribution is then carried until we assume that the man changes his time again at 3 P.M., which is indicated by the ninth column, and the letter *F* indicates that he has been placed upon the concrete gang, and we will asssume that he so continues until the completion of the day. By even a casual observance of this man's time for the day, it is evident that he spent 3½ hr. upon back fill (taking 1 hr. for noon), and assuming that the gang quit at 6:00 P.M. that he spent 3 hr. upon concrete, making a 10-hr. day. This system has been found to work satisfactorily, either upon a weekly report basis or upon a daily report basis, and being used uniformly on all contracts, whatever the size of the job or character of the work, the office work has been greatly simplified.

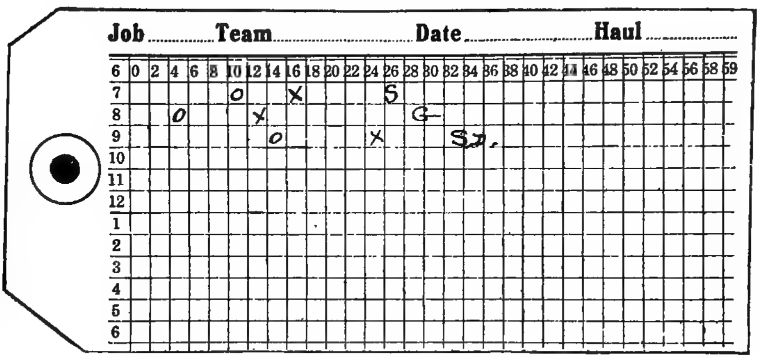


FIG. 94.—Team card (see p. 303).

On the back of the time report are shown all of the matters ordinarily appearing in the life of any contract. A complete car report is made; also items of expense and amount of cement used. In the latter case, the opportunity is also given for the dates when the cement was used and where used. On the right-hand side a complete report of the job is given. The manner in which this is done is apparent from the form given; but especial attention is called to the fact of the opportunity to check up current work with past work; and also to compare the total amount of work done to date. The items are printed in the same order by rubber stamps in the item column the same as they appear upon the reverse side of the sheet under the distribution. If the timekeeper is unable or not competent to make a report of the amount of work accomplished, one of the supervising engi-

Inspector's Daily Report.

Date.. *Weather*..........

Street...

....

....

Condition of Street—dry, wet, etc...................................

....

....

GRADING.

Hour of Day	8	9	10	11	12	2	3	4	5	[illegible]	Total
Graders											
Wheelers											
Wagons											
Plows											
On Dump											
Foreman											
Water Boy											
C. Y. Graded											

ROLLING.

Rolling Sub-grade											
Rolling Brick											
Men on Roller											
Sq Yds. Rolled											

CONCRETE.

Hand Mixers											
Wheelers, R & S.											
Wheelers, Concrete											
Men on Mixer											
Engineer											
Concrete Wagons											
Spreaders											
Tampers											
Foreman											
Water Boy											
Teams—Hauling Rock											
Teams—Hauling Sand											
Teams—Hauling Cem.											
Sack Cement used											
Sq. Yds. Spread											

BRICK LAYING.

Hour of Day	8	9	10	11	12	2	3	4	[illegible]	6	Total
Brick Wheelers											
Brick Layers											
Others											
Foreman											
Water Boy											
Sq. Yd. Layed											

SAND CUSHION.

Men											
Sq. yd. Cushion made											

FILLER.

Screening Sand											
Mixing, dry											
Mixing, wet											
Sweepers											
Wheelers											
Foreman											
Water Boy											
Teams Hauling S.											
Teams Hauling [illegible]											
Sq. yds. Filled											
Sacks Cement											
Yds. Sand											

EXPANSION JOINTS.

Men											
Bbls. Pitch											

BUILDING CURB.

Graders											
Setting Forms											
Foundations											
Mixers, hand											
Mixers, at machine											
Wheelers, sand											
Wheelers, cement											
Concrete wagons											
Concrete wheelers											
Tampers											
Finishers											
Removing Forms											
Backing up											
Sacks Cem.											
Linear feet built											

General progress of work ....

Any unusual or important matter to report ? ....

....

....

Signed...
Inspector.

FIG. 95.—Inspector's report, paving (see p. 304).

neers cooperates with him to secure this information, so that the report may be a complete one.

In the matter of the office work, complete pay rolls are pre-

Tuesday, Apr. 10-'06.									
Building "A"	17½	20	22½	30	35	50	60	70	
Brickwork.									
Bricklayers							64	8	$44.00
Laborers.			80						18.00
Carpenter Work.									
Sheeting				72	6				23.70
Setting Frames.				18	3				6.45
Building "C"									
Concrete.									
Hauling Gravel (74 Loads)	40				38				20.30
Moving Mixer	50			10	2				12.45
Bailing Sacks (Finished 2³⁰ P.M.)	14								2.45
Building "D"									
Excavating.	150								29.25
Superintendent.									5.00
Timekeeper – Waterboy									3.25
									$164.55

Left Hand Page. Right Hand Page.

FIG. 96.—Timekeeper's book, building work (see p. 305).

A, B & C Shops. Concrete Foundations.—Bldgs.

Date		Cement	Sand	Stone	Form Materials	Supplies Fuel		Erecting Plant	Forms Labor	Mixing	Placing	Teams
Apr. 24	Pay Roll Apr. 13–19								130 50	190 30	80 75	42 00
"	Cement. 300 bbls. @ 1.51	453 00										
"	Stone 300 cu. yds. @ 1.00			300 00								
"	Sand 120 " " @ 0.60		72 00									
"	Lumber 10 M @ 20.00				200 00							
Apr. 26	6" Belt 30' @ 0.20					6.00						
May 2	Pay Roll Apr. 20–26								140 00	125 00	95 50	21 [illegible]
	ENG.–CONTR.											

FIG. 97.—Loose leaf ledger sheet (see p. 310).

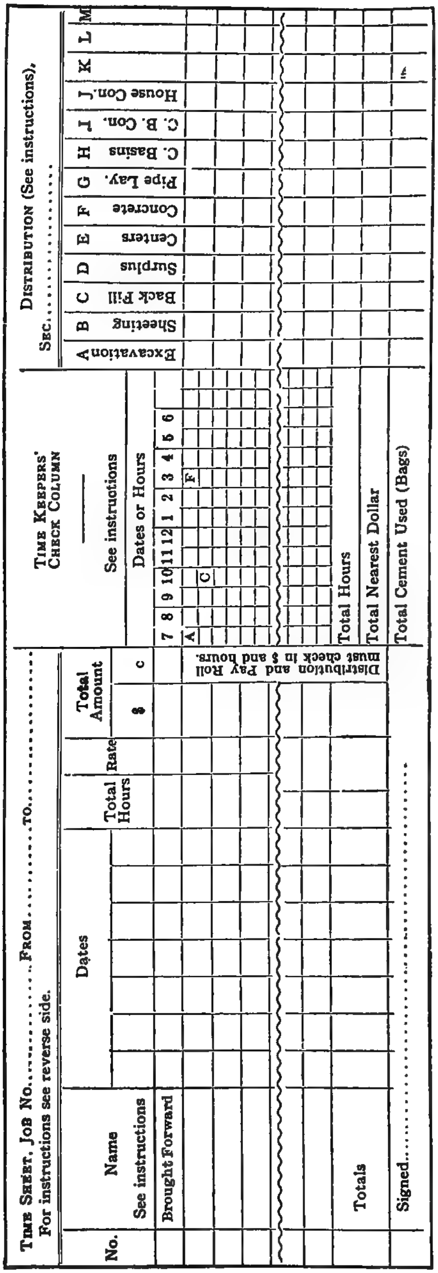
pared from the time sheet side and the cost of the work is posted in the cost record book. This cost record book, however, is not essential, but only as a matter of permanent record, as the sheets

themselves show total cost to date at all times of each item of work.

This form of timekeeping would be of value because of the system of uniformity alone, even if no regard were given to the other features mentioned, although the above companies using this report are satisfied that they are securing more valuable data by this form than they would have ever been able to do by previous forms used. The value of the uniform time sheet lies in the education of the timekeepers, resulting in a more efficient working force. Under the old system with individual time sheets, prepared especially for each job, the forms of the time sheets were many and various, and, for this very reasons timekeepers presumed to incorporate their own ideas and make changes and innovations, resulting in a bunch of data that required hours, and generally the personal attendance of the timekeepers, to work out.

Passing from the time sheets, Figs. 98 and 99, pay rolls, Fig. 100, and the cost record book, the next feature of the system of information or cost data consists of progress charts. These of course, will vary with any job according to the character of same, and, as they are used by nearly every large construction company, it will only be necessary to say that blue prints are prepared (generally blue line prints) upon which the timekeeper is able to color in the work completed each day of the week, marking dates thereon and turning such charts into the office. These progress blue prints thus form a permanent record of the progress of the work and also form the basis for the determination of the amount of work accomplished from time to time.

In connection with these progress charts, however, Mr. Moore has a unique summary progress chart upon which is carried forward and maintained a continuous record of the job, the information being obtained from the summary report of the time sheet. One of these summary progress charts is shown by Fig. 101. The essential idea of this summary progress chart is to have at all times a condensed, complete history of the work, not so much with reference to the detail unit cost of each item of work, but more especially with reference to a comparison between the estimated total cost and the actual total cost. This comparison allows an intelligent idea to be made of the portion of the work done, and indicates at once whether the actual cost is less than the estimated cost or exceeds it. The general form of this summary sheet is a standard, but of course will vary



TIME SHEET, JOB NO.........FROM.........TO.........
For instructions see reverse side.

TIME KEEPERS' CHECK COLUMN

DISTRIBUTION (See instructions).
SEC. ....

No.	Name See instructions	Dates	Total Hours	Rate	Total Amount $	c	See instructions Dates or Hours 7 8 9 10 11 12 1 2 3 4 5 6	A Excavation	B Sheeting	C Back Fill	D Surplus	E Centers	F Concrete	G Pipe Lay.	H C. Basins	I C. B. Con.	J House Con.	K	L	M
	Brought Forward																			
						Distribution and Pay Roll must check in $ and hours.	A C F													
	Totals						Total Hours													
							Total Nearest Dollar													
	Signed.........						Total Cement Used (Bags)													

FIG. 98.—Front of time sheet (see p. 316).

FREIGHT AND CAR REPORT

Car		Loading		Received		Unloaded	
Initial	Number	Kind	Amount	Place	Date	Place	Date

EXPENSE

Name	Items	Amount	

CEMENT USED (BAGS)

Dates	Where Used					
Total						

REPORT OF WORK. JOB NO.............FROM.............TO..........

SEC........ Item	Previous Report			This Period			Total to Date.		
	Pay Roll	Quant.	Unit Cost	Pay Roll	Quant.	Unit Cost	Pay Roll	Quant.	Unit Cost
Excavation, cu. yds.									
Sheeting, lin. ft.									
Back Fill, cu. yds									
Surplus, cu. yds.									
Centers, lin. ft.									
Concrete, cu. yds.									
Pipe Lay, lin. ft.									
C. Basins, No.									
C. B. Con., lin. ft.									
House, lin. ft.									

Signed[1] ______________________

INSTRUCTIONS.

It is intended that this sheet shall be used for all jobs, whether timekeeper makes report to pay-roll clerk daily, weekly, or monthly, and is to be used also for making summary reports. In using this time sheet side, always place date at head of column, and when marking out summary sheet place daily dates in the name column. In using the distribution side, the column marked "Timekeeper's check column" must have dates placed at the head corresponding to the time sheet side, and each column represents one day, the distribution being taken four times per day and marked inside of the four little squares, using distribution letter. However, for daily sheets, each vertical column represents one hour, and separation of time must be checked to the hour. Distribution columns will be headed by rubber stamp for each job and each man's time must be distributed under the proper columns and the totals reduced to dollars and shown at the foot of sheet, except that for summary sheets, total for each day will show opposite same. Timekeepers and engineers will co-operate to insure that summary sheets are correct as to time distribution and amount of work done. Daily time sheets must be turned in to the office at the close of each day; weekly time sheets each Thursday evening, and bi-monthly or monthly sheets will be separated and turned in at least once each week. No change of rate of pay will be allowed between pay-roll periods.

No deviation from these instructions will be allowed on any job.

FIG. 99.—Back of time sheet (see p. 316).

THE MOORE-MANSFIELD CONSTRUCTION CO.
INDIANAPOLIS
PAYROLL

From......190.. To............190..   (......) Gang No. (....) At.. ..)

Contract No. (........)..........................At..........................)
(Contracting party)   (Location)

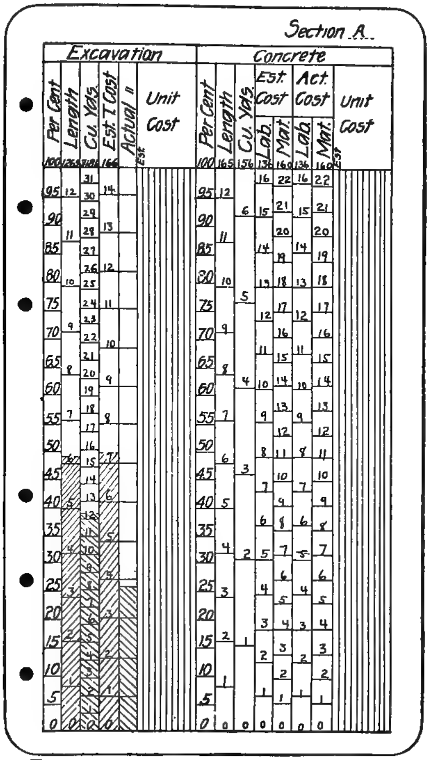
We hereby acknowledge receipt of the amounts set opposite our names as payment in full of all claims to date.

No.	Man's No.	Names	1	2	3	4	5	6	24	25	26	27	28	29	30	31	Total Hours	Rate	Total Amount Pay roll	Deductions								Net Am't Due	Paymaster's Memora'dum of Method of Payment	No.
																				Co. Board	Co. Supplies		Cash Advances		Miscellaneous					
																					Item	Am't	In favor of	Am't	In favor of	Item	Am't			
1																														1
2																														2
3																														3
4																														4
5																														5
6																														6
7																														7
8																														8
22																														22
23																														23
24																														24
25																														25
26																														26
27																														27
28																														28
29																														29
30																														30
31																														31
		Totals																												

Correct .... Pay Roll Clerk.   Correct .... Supt. Const.   Approved .... Treasurer.   Paid.............190.. .... Paymaster.

FIG. 100.—Payroll (see p. 329).

with each job as to the number of items making up the complete contract. Referring to Fig. 101 the chart illustrated is being used in connection with a sewer contract, and a brief description will be given of the manner of the use of this chart. In this case, the sheet is ruled so as to cover two classes of work only; namely, excavation and concrete. Under each one of these



Eng-Cont

FIG. 101.—Progress chart (see p. 329).

headings, the first column is a percentage column. In using the sheet, the length of the section is plotted in the column marked length so that the complete length corresponds to the 100% line; the same is done with the estimated amount of cubic yards of material to be handled corresponding to such length. The estimated cost is then plotted in dollars, the total, however, being made to correspond with the 50% line in the percentage column.

Now, as the work proceeds, the actual cost is plotted on the same scale as the estimated cost and shows at all times the relative proportion. No matter what the total length of the job or the total length to be handled, if the scale upon which same is plotted is so made that the length corresponds with the 100% line, the general manager is able to tell, at all times, just where any one section of the job stands. For instance, on the chart used for section *A* of the sewer, above mentioned, the 100% line equals in the length column 1,265 ft. = 3,186 cu. yd. = an estimated cost of $733.00, the latter point being opposite the 50% line. Now, for instance, on the first day of August, the actual feet of sewer constructed was colored in the length column as about 610 ft.; immediately upon the percentage scale line, we see that this amounts to about 47%, and in the yardage column, this gives us 1,550 yd. Upon the estimated cost scale the amount to be expended for this amount of work was about $375.00. As an actual fact in the case mentioned, the actual cost to the date corresponded exactly to the amount of $375.00. At once, by casual observation, the general manager or superintendent is able to tell from very meager information just where the job stands. Given the length, the cubic yards and estimated cost for the section may be read off the chart and the actual cost compared. If the record is made in number of cubic yards, and so plotted, the corresponding length may be read off. In either case, the percentage of completed work may be compared with the percentage representing the actual cost and in turn compared with the percentage indicating the estimated cost

The chart is also of great value on any section, especially where the work is of a character that is continuous in its operation and continues in the repetition of certain units of work, in that the timekeepers or superintending engineers can read directly from the chart the data necessary to complete the report of work done on the reverse side of the time sheet.

In the particular chart shown, various lines were also drawn for unit cost, so that at various times during the progress of the work, the fluctuating unit cost might be readily compared. This, however, is not essential, and, in fact, it is but seldom used.

In connection with the particular sewer job referred to above, in as much as the sewer itself was of various sizes and to be built under varying conditions, the general progress blue print was made as shown by Fig. 102. Attention is called to the

fact that each individual size of the sewer or change of conditions is indicated as a section and all reports are made upon the basis of such sections. Where the general character of the work is the same, and the work is to be handled by the same methods, a letter is used as indicating a general division and numerals added to indicate the sub-sections.

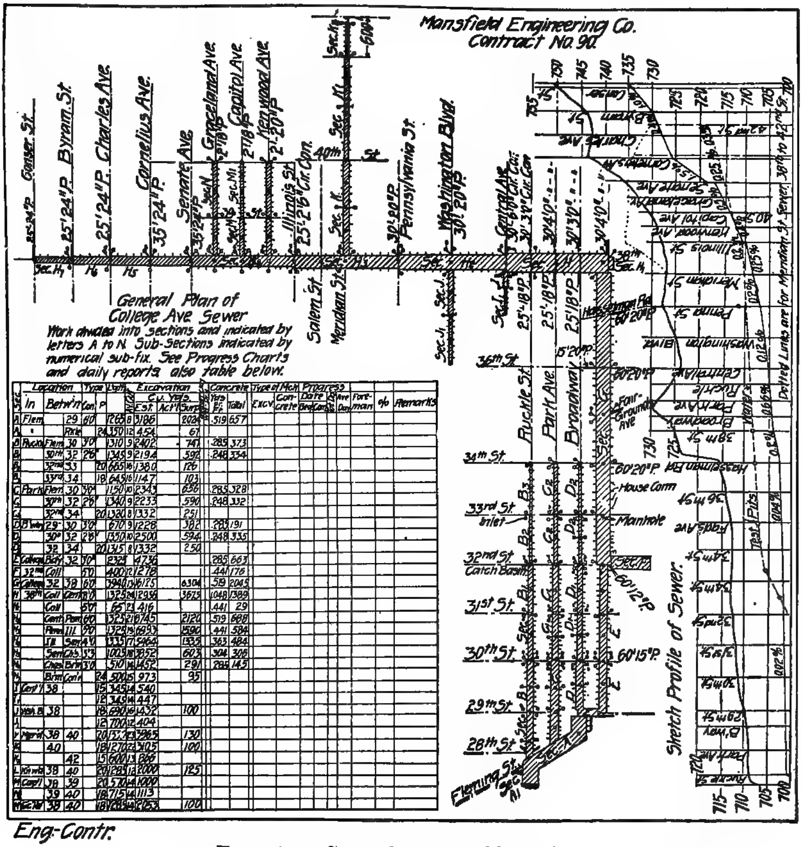


FIG. 102.—General progress blue print.

The costs of work, however, and amounts of work accomplished are kept by sections and sub-sections, so that when the job is completed the cost of each size sewer under the conditions met with can be readily determined. In the particular case mentioned, the principal item being excavation, concrete, or pipe, the summary progress charts as just described are kept only on

these particular items of work, although the miscellaneous items of work always appear and are carried forward upon the time sheet distribution and reports of work done.

The particular contract referred to above consists of about seven miles of main sewer, of which four miles is all concrete construction, three miles of pipe work, and there are also some four miles of miscellaneous pipe work, making in the aggregate eleven miles. The same system of cost recording is being used at this time to keep in tab with the construction of bridge work, the construction of a boulevard, embankment work, and also for the construction of several reinforced concrete buildings.

(The blank was 8½ in. long by 5⅜ in. wide. In the reproduction words in *italics* and figures are shown to illustrate use of blank in a specific case.)

Cost Keeping on Sewer Work.[1]—Mr. Keith O. Guthrie has contributed an excellent article, which we reproduce here:

FOREMAN'S DAILY PAY ROLL REPORT.

Location....*14th Avenue*....*No. 2*....*96" Sewer*..................Date,....*August 7, 1907*

Itemized Pay Roll.			Work Done.		Pay Roll Distributed.
Foreman *1* days at	*4 00*	*4 00*	*General Night Watchman and Water Boy*		*2 25*
Engineer *1* " "	*3 50*	*3 50*	Excavation completed to station	*18.40* Cost	*19 25*
Labor *1* " "	*3 00*	*3 00*	Sheeting " " "	*18.30*	*8 25*
" *27.4* " "	*1 75*	*47 95*	Foundation pl'nk " " "	*18.00*	*2 63*
" *11.8* " "	*1 50*	*17 70*	Backfilling " " "	*16.90*	*3 00*
" ...... " "			Sheeting Pulled " " "	*17.10*	*2 62*
Carts *1* " "	*3 00*	*3 00*	Concrete Invert " " "		
Teams *2-10* " "	*6 00*	*1 20*	Brick Invert " " "		
Hoister 1 " "	*2 00*	*2 00*	Concrete Sides } " " "	*17.48*	*29 62*
Water boy 1 " "	*75*	*75*	Concrete Roof } " " "		
			Steel Bars set " " "	*17.48*	*3 50*
			Forms set to station	*17.48*	*7 25*
Total day's pay roll		*83 10*	Forms, Pipe laid to station		
			Manholes built to-day		
			Other items *Pump*		*53*
			Teams working *Cement*	*17.48*	*1 20*
			Carts working *Gravel*	*17.48*	*3 00*
			Total day's pay roll		*$83 10*
			Signed——*L.—W.*—— ....Foreman.		

FIG. 103.—Cost keeping on sewer work—blank for daily report of foreman.

The report cards, Figs. 103 and 104, were designed to gather detailed cost records from scattered sections without increasing the ordinary clerical force. They have been used on a large sewer contract in charge of the writer, producing records in handy shape for daily and semi-monthly comparison, easily compiled into compact totals for future reference. The entire

[1] *Engineering-Contracting*, Oct. 23, 1907.

extra expense of the working system has only amounted to the first cost of printing.

It is common practice, and properly so, on cost reports to print the desired items of distribution and adhere to them throughout. Otherwise it is the tendency to increase the number of special items ad infinitum, making comparison difficult. However, on these reports, three extra lines were left to cover

FOREMAN'S DAILY MATERIAL REPORT.

Location *14th Avenue No. 2 96"* Date, *August 7, 1907*

Full cement bags on hand last night		*84*
" " " received to-day		*160*
Total		*244*
Full cement used to-day on conc. invert		
" " " " " brick "		
" " " " " conc. sides }	*156*	
" " " " " " roof }		
" " " " " manholes		
" " " " " pointing up, etc.	*1*	*157*
Balance on hand to-night		*87*

Empty cement bags on hand last night		*7*
Full bags used to-day		*157*
Total		*164*
Empty bags sent in to-day		*140*
Empty bags balance on hand to-night		*24*

Materials received.	From.	Amounts.
		47—4 x 6—16-ft.
		12—4 x 6—14-ft.
Lumber	E.——— N.———	*1120′ $\frac{7}{8}$″ roofers.*
Steel Bars	*Car No. P R R 7284*	*120—$\frac{7}{8}$—15* ft.
		120—$\frac{3}{4}$—19-ft.
		75—$\frac{5}{8}$—30-ft.
Sheeting and bracing left in place	*None*	
	L.——— W.———	Foreman.

FIG. 104.—Cost keeping on sewer work—form for foreman's daily material report.

special conditions, such as pumping, laying sub-drain, etc., occurring only on one or two sections. It is often difficult to secure, on daily reports an accurate statement of the amount of work done. This is easily obtained on sewer work by referring everything to the stations or "grade-boards." This method obviates everything and the daily distances check up when totaled for any period of time. Indeterminate items, like teams, can be arbitrar-

ily coupled with some suitable item, such as Excavation or Arch.

To get an accurate distribution of a pay roll it is necessary, of course, to have the amount of the pay roll. That the foreman may find this readily, and, in part as a reminder, the different classes of labor are tabulated on the left.

Toward the end of the day the foreman first jots down the stations of completed work, then from his time-card, having simply the check numbers, rates and hours worked, he draws off his day's pay roll, finding it to be, as in the case taken, $83.10. He now distributes first the minor items, which is readily done from memory. For example, the Bracer and his three helpers worked on "Sheeting;" the two men on "Blackfilling" car; the three who "Pulled Sheeting" for 5 hr.; the two bending and setting "Steel Bars;" the two carpenters and one laborer on "Forms," and so on, until there is left only Excavation and Concreting. As a rule the men who have been in the ditch can be readily counted up, and Concrete Invert, or Arch, gets the balance of the pay roll. The last item, of course, gets some of the odds and ends, but that is better and far safer as a basis for future estimating, than heaping them into a "Miscellaneous" item by themselves.

These reports are daily collected by the general timekeeper and checked up by him as to correctness of pay roll amount. They can then be used for comparison between different sections, or between different days on the same section, without further tabulation. At the end of a half month it takes not more than an hour to foot up the totals of a section and post on the same card, which is then ready to file in a card cabinet as a permanent record.

The "Material" report, Fig. 104, was gotten up to catch the elusive cement empties and to follow the quantities used on different parts of the sewer. By checking with the storekeeper's records, the loss of bags or waste materials can be learned soon enough to take advantage of it.

Cost-keeping Blanks for Building Construction.—We are indebted to the late Chas. J. Steffens of New York City for an excellent description of a simple system which is susceptible of wide application. It appeared in *Engineering-Contracting*, July 4, 1906, and is given below.

The Guarantee Construction Company use on their small contracts a form of report, illustrated herewith, Fig. 105, which,

DAILY REPORT

GUARANTEE CONSTRUCTION CO., NEW YORK

Job 765 Date 5/22/06

Number of Men	Earth Excavation	Rock-Excavation	Pumping	Concrete	Forms	Waterproofing	Brick Masonry	Stone Masonry		Heavy Timber Raising	Heavy Timber Framing	3-in. Flooring	2-in. Flooring	1-in. Flooring	Roof Sheathing	Sides and Partitions Heavy	Sides and Partitions Light	Heavy Studding	Light Studding	Doors and Windows and Trim	Machinery	Roofing	Painting	Hardware						Extra Work Stable	Extra Work	Extra Work	Foreman	Gen. Exp.	Repairs to Plant	Total Hours	Rate	Amount	
16	55			95	10																															160	17½	28	00
18				40	20						80																			40						180	33⅓	60	00
2			20																																	20	25	5	00
1																																	10					4	00
Total:	196		5.00	30.00	8.41						26.66																			13.38			4.00				97.00	97	00
																																							75
					25																			.50													.25	97	75
Cash Expenses of To-Day					Twine																			Expressage on bolts												Total Expenses			

Weather Clear

NOTE. — Keep each kind of extra work separate.

A.P.S. Foreman.

Fig. 105.—Daily time report, building work. (Actual size, 6¼ × 13 in.)

essential information for a detailed cost record. The report is of course sent to the office daily.

The first column gives the number of men, the same horizontal line being used for all men receiving the same rate per hour. Thus, in the report illustrated, there were 16 men at 17½ cts. per hour, distributed as follows: Excavation, 55 hr.; forms, 10 hr.; concrete, 95 hr. The total hours at this rate are shown at the right of the sheet, namely, 160 hr.; the rate, 17½ cts., making a total cost, for this rate of wages, of $28.00.

The men paid at other rates are entered in a similar manner and the vertical column of totals is footed up. The horizontal column for totals, near the bottom of the sheet, shows the cost for the day of the various parts of the work, as, for instance: Excavation, $9.61; concrete, $30; forms, $8.66; etc. This column is also footed up and the two footings made to check.

In the column of "Cash Expenses of Today" appear all such items as carfare, etc., which the foreman pays himself. These are entered in the vertical column to which they are chargeable, as, for instance, in the case of twine secured for use in construction of the forms, the cost of twine appears under forms. These expenses are footed up and added to the total already found, giving the grand total as shown. Upon this daily report must appear all charges for which the foreman expects to receive payment on the fortnightly payroll.

When the report reaches the office it is immediately checked to ascertain if it is correct, and if so the proper entries are made on the daybooks under the contract covered by the report. Thus on Tuesday afternoon our books show the cost of each contract or of any particular item of a contract up to the end of Monday's work.

All material is ordered by the triplicate order system, by which three copies of each order are prepared, one being forwarded to the firm from whom the material is purchased, another sent to the foreman on the work, and the third retained for an office copy.

As soon as material is delivered on the job the foreman checks such material and if he finds it correct sends the copy of the order which he holds back to the office, marking it O. K. and giving the date on which material was received. When this

while requiring but little time to prepare, yet supplies all the returned copy reaches the office, the material covered by the order is at once charged against the contract under the proper distribution of forms, concrete, etc.

The books in which these cost records are kept are of the loose leaf type. A number of the pages are headed with the name and number of the contract and one page is allowed for each item of distribution and is headed forms, concrete, etc. Should more than one page be required for any item the additional sheets may be inserted at any time. The pages are ruled with a column at the left for the date, then a head space for the description of the order. Beyond this is a column for the order number and two columns, one for entry of cost of material and another for entry of labor cost. The manner of ruling these pages is shown above.

At the end of each month, or whenever desired, these columns may be footed up showing the cost up to the previous night on any item of distribution of any contract and subdividing such cost into material and labor. A monthly data sheet is prepared for each contract showing the estimated costs of the various items and the actual cost to date. At the completion of the contract another sheet is prepared showing the estimated costs and actual costs as well as the estimated unit prices and the actual unit costs.

In connection with these reports another form is used which is also illustrated herewith, Fig. 106. This has, as will be seen, spaces provided for reporting material received, material required, material which the foreman has found it necessary to order and such other information as he considers it advisable to communicate to the office.

The report blanks are furnished to the foremen in the form of pads with alternate sheets punched with small holes along the top close to the binding. These sheets are torn out and sent to the office, while the next sheet, on which a carbon copy of the report appears, remains in the book or pad for the foreman's record.

It has been found that the use of these reports with spaces provided for the above purposs will tend to call to mind the various matters when the foreman prepares his report in the evening, and matters which otherwise would be forgotten are called to the attention of the office.

GUARANTEE CONSTRUCTION CO.

NEW YORK CITY

Job 765 Date 5/22/06

The following material received to-day: Bolts etc on order #1087 — Timber on order #1093 Cement on order #1081

Please order the following material: 1/3 doz 12 qt galv. pail. — 150 ft 3" dia. rope

Please hurry material covered by requisition No. #1067 — #1069

I have ordered the following material to-day:

MATERIAL	CHARGE TO	NAME OF FIRM	PRICE	
3 kegs 10d wire nails	Hardware	Cronley Co.	2	30

Do not report on this sheet the purchase of any material you have paid for.

Remarks: Earth excavation will be completed tomorrow — Forms are all constructed and cost on this will in future be simply for moving from place to place.

A.P.L. Foreman.

FIG. 106.—Material report. (Actual size 6¼ × 13 in.)

The Cost-keeping System of the Aberthaw Construction Co.[1]—The following is an abstract of an article by Leonard C. Wason, president of the Aberthaw Construction Co., of Boston.

In order to have an intelligent understanding of the meaning of the figures hereinafter given, the method of collecting data will be described. When making up an estimate of the cost of a building, in scaling the plans, it is found convenient to take off the volume of excavation and backfilling, the cubic feet of footings, foundation and wall, the square feet of forms for walls of foundations and above grade, the lineal feet of belt courses, moldings, cornices, etc., also the size of special features of exterior treatment. Similarly the superficial areas of column and floor forms are measured by themselves. Concrete of each different mixture is scaled off in cubic feet and totaled separately. Steel of each kind is taken off in pounds; granolithic finished surfaces in square feet, and so on in detail every item is measured. As the work progresses it is desired to know weekly how the actual experience compares with the estimate and at completion to compile correctly the costs of each item to compare with estimate and to aid in obtaining the true cost of future structures of a similar kind. The method of accounting was developed to fit the estimate.

In the year 1898 daily time reports were designed having a number of columns for ease in sub-dividing the time of the workmen. At the head of each column the timekeeper puts index numbers or letters to show the kind of work being done, and below, the actual time the men worked. On blank spaces at the extreme right of the report the timekeeper inserts in writing the amount of each kind of work done and the amounts of the principal materials used. The experience of eight years has required no change whatever in the principles first adopted. The only change in the forms has been to increase the number of vertical columns so that a large number of sub-divisions can be used without troubling the timekeeper to re-write the names on another sheet. At the present time ten vertical columns (Fig. 107) are used for recording time, with the names of the workmen at the extreme left, two columns being left at the right for the rate per hour and the total amount. At the beginning of a job written instructions are given as to how the work

[1] *Engineering-Contracting*, Jan. 13, 1909, and March, 1906.

is to be subdivided into items in the reports. A standard method of classification has been adopted as follows:

The principal sub-divisions are given a capital letter. Thus, everything whatsoever relating to concrete masonry is given the index letter *M*; excavating of all kinds, including work incidental

JOB No. *747* LOCATION, *Attleboro, Mass.* ALBERTHAW CONSTRUCTION CO., BOSTON

DATE, *Aug. 1, 1909.* DAILY REPORT

Name of Workman	Time *Ofs*	Time *Maaf*	Time *Maaw*	Time *Maac*	Time *Maof*	Time *Maow*	Time *Mef*	Time *Meaf*	Time *Ceak*	Time *Meaw*	Office Rate	Office Amt.		Put at head of proper column or against each name index of work performed.
1 *Closby* Foreman	9½										30 00		5 88	State each kind of work done. Amount of Cem. and Materials used.
2 *MacIntire*	9½										15 00		2 64	Weather
3 *Cook, John*	9½										41		3 89	Temperature: 7 A. M.
4 *Angwine*			5				4½				37½	*Maaf*	19.38	1 P. M
5 *Blanchard*		7	2								37½	*Maaw*	49 45	5 P. M.
6 *Cameron*			9								28	*Maac*	3 11	
7 *Clough*		7		2							37½	*Maof*	3 27	
8 *Cook, James*		4				5					41	*Maow*	9 05	
9 *Dunne*					3	6					37½	*Mef*	11 41	
10 *Dupont*		5	4								37½	*Meaf*	12.34	
11 *Emmons*			5				4				.37½	*Ceak*	3.88	*Ceak = Motor Shaft.*
12 *King*			[illegible]								37½	*Muaw*	3.61	
13 *Lambert*			4			5					37½	*Meaw*	2 75	
14 *Lemieux*					3	1			5		25	*Water-boy*	.50	*Meaf 650 c. f.*
15 *Lovejoy*											37½		150.42	*Meaw 48 " · (48" th)*
16 *O'Connell*		6	[illegible]	3							.37½			*" 11.6 " (10 ")*
17 *O'Hara*		6		3							41			*" 21 " (21 ")*
18 *Parrus*		9									.28			
19 *Peterson*			9								34			*140 bags cement used.*
20 *Proulx*			[illegible]								.37½			
21 *Roberge*		9									[illegible]			
22 *Sanford*			2								.37½			
23 *Spittle*			9								37½			
24 *Steves*			7							2	[illegible]			
25 *Turnbull*			2						7		[illegible]			
26 *Valignette*			8								.37½			
27 *Riley*							9		*Muaw*		.28			
28 *Phelan*									9½		.25			
29 *Martin*			3			6					[illegible]			
30 *Johnson*			9								20			
31 *Spenser*			5				2	2			[illegible]			
32 *Lawson*								9½			25			
33 *Geaudaux*								4½	5		.22½			
34 *Russ*	*Waterboy* 9										.05½			
35 *71*			5					4½			.28			
36 *651*			5					4½			.20			
37 *652*			5				1½	3			.20			
38 *655*			5				2	2½			20			
39 *676*						7	2½				.20			
40 *677*			5				4½				.20			
41 *678*					5		4½				.20			
42 *681*							4½			5	,20			
43 *682*			5				4½				20			
44 *684*			5					4½			[illegible]			
45 *686*			5					4½			.20			
46 *688*			5					4½			20			
47 *690*			5		2		2½				20			
48 *692*			5					4½			.20			
49 *696*			5					[illegible]			20			
50 *697*								4		5	.20			
Work performed.														Approved

FIG. 107.—Daily time report.

thereto, the letter *D;* all work connected with plant the letter *P,* and so on, there being only six or seven sub-divisions to indicate every building operation. To indicate the kind of work vowels are used. Thus, the vowels beginning with *a* all relate to form work, as: *a,* centering complete; when done by separate operations *aa* is making, *ae* is setting, *ai* is straightening up or bracing,

ao removing after being used, and *au* cleaning up and handling ready to be used again. All labor connected with mixing and placing concrete or with handling materials for same goes under the head of *e;* all work in connection with plant, receiving, erecting, taking down, shipping and repairing, is indicated by the vowel *i*. Thus *i* means receiving and setting up plant ready to work, *ia* taking down, removing and shipping, and *ie* repairing. The consonants are used to indicate different parts of a structure in which certain work is done. Under classification *M*, *b* stands for footings, *C* columns, *d* foundations, *f* floors, *g* stairs, etc. Under classification *P*, *f* stands for boiler, *g* for horizontal engine, *h* for vertical hoisting engine, *l* for elevator, *m* for mixer, etc. Thus our timekeeper places at the head of a column when he is reporting concrete floors, for the placing of forms *Maaf*, for concrete *Meaf*. If a mixer is being set up ready to work the report would read *Pim* and later if it was repaired it would be reported under *Piem*.

This is not so complicated to use as it may appear to read, and experience has proved that every man who knows enough to keep time can use the system with a few days' experience. The principle is to make the least amount of clerical work to the timekeepers on the job, as they have plenty of other work to do. In addition to sub-division of time as above set forth, it is the duty of the timekeeper to report the number of barrels of cement mixed in a day, which is usually done by the man in charge of the mixer counting the empty bags, and in addition the actual volume of concrete measured in place. From this, knowing the proportions, it is a very simple matter to obtain the amount of sand and stone used and also to see if the right amount of cement is being used.

Carpenter work on forms is reported by the number of square feet of surface in contact with the concrete erected. Thus walls are measured two sides without deducting doors and windows, as it is usual to let the form work run straight across these unless it is impossible on account of mouldings, in which case the framing of the opening will cost as much as the form work omitted. Beam floors are measured around the perimeter of the beam and the flat surface of the panel and around the perimeter of girders. No deduction is made for the loss of area by the intersection of beams and girders, and small openings in the floor are not deducted. Anything as large as an elevator or

stairway is usually deducted. Form work for columns is measured for entire area of surface contact between wood and cement, all four sides.

These reports are made out on the job daily and sent to the office. The bookkeeper works these reports up into units of measurement, as cost of labor per cubic foot of concrete and number of cubic feet of concrete per barrel of cement, number of square feet of form work erected, etc., and from this it is easy to obtain the unit costs hereinafter given. The bookkeeper can take the reports of four or five jobs, employing in the aggregate 500 or 600 men, and in a single day work up the complete report for a week's time; thus it will be seen that there is really little extra labor involved in the subdividing of reports into a useful form over merely reporting the time so that the pay roll can be accurately made.

The system employed has appeared of sufficient value to others to warrant its being briefly outlined in Gillette's "Hand Book of Cost Data," pages 14, 15, and 19, and a description of it also appeared in *Engineering-Contracting* of March, 1906.

Materials received on the job are reported on cards especially printed for the purpose, listing the principal materials which are reported, in order to save work of the timekeeper in reporting materials accurately.

When a job is entirely completed and the ledger account is closed, a master card is worked out giving the complete history of the cost. On one side of the card are written the items which went into the original estimate, such as excavation, backfilling, footings, foundations, columns, floors, walls, stairs, etc., etc. In parallel columns are placed the actual amount of the estimate with the actual experience, reduced to cost units, such as cubic feet, square feet of form work, etc., and the percentage of profit or loss between the estimate and actual results. On the reverse side of the card the principal items are worked out more in detail. Thus form work is reduced to cost of labor, lumber and nails, wire or other sundries used in the forms per square foot of surface. Concrete is itemized into the superintendent's general labor, labor of mixing and placing, cost of cement, sand, stone; miscellaneous expenses such as teaming, plant and other general items, reduced to cubic feet measurement, which makes the total cost of the concrete in place in each division of the building itemized for ready reference when making

up future estimates on work of a similar character. An example of this form is given by Fig. 108.

It is well known that the costs of materials and labor in different parts of the country vary somewhat. Having the unit items all sub-divided, as above stated, into their elementary parts, it is an easy matter after determining the cost of materials in any locality to make the exact corrections to the results obtained on a previous job. Similarly, when a difference in the rate per hour for wages is known, if the same efficiency is obtained from

Job No. 747.
Date May 24th, 1906. Mill, Tappan Bros., Attleboro, Mass.

	Proposal.	Actual Cost.	Per. Cu. Ft.	Profit.	Loss.	Per Ct.
Total	$35,164.55	$31,330.48	......	$3,834.07	$.......	11
Excavate	790.00	823.18	.021	....	33.18	..
Footings and Fr.	1,738.00	1,033.57	.137	704.43	....	..
			Per sq. ft.			
Exterior walls	1,955.00	2,162.02	.190	....	207.02	..
Wall and Fr. centers	1,520.00	3,630.08	.125	....	2,110.08	..
Floors, 6⅜" thick	8,883.00	6,542.16	.339	2,338.84	....	..
Roof 5¼" thick	2,869.00	1,713.51	.237	1,155.49	....	..
			Per l. ft.			
Columns, 20x20"	832.00	676.65	1.470	155.35	....	..
Stairs	883.00	910.35	.912	....	27.35	..
			Per sq. ft.			
Tool surface	469.00	636.53	.056	....	167.53	..
Ornaments and cornice	348.00	164.33	....	183.67	....	..
Ventilators on roof	44.00	35.64	....	8.36	....	..
			Each.			
Set windows and door frames	852.00	729.99	2.19	122.01	....	..
			Per sq. ft.			
Interior partitions	1,770.25	1,656.35	.189	133.90	....	..
Bolts and iron work	253.00	257.06	....	....	4.06	..
Stair railing and grill	387.00	654.00	....	....	267.00	..
			Per M.			
Screens and setting	1,086.00	835.12	52.17	250.88	....	..
2" Spr. plank and laying	2,839.00	1,431.69	33.30	1,407.31	....	..
7-8" Maple plank and laying	1,738.00	1,788.88	89.44	....	50.88	..
Motor shaft	379.50	533.19	98.89	....	153.69	..
Motor shaft found	98.00	70.07	.....	27.93	153.69	..
Roofing and conductors	1,255.00	1,026.06	.....	288.94	....	..
			Per sq. ft.			
Paving	1,009.00	647.54	.094	361.46	....	..
Retaining wall—						
Centers, per sq. ft.	....	......	.211	....	....	..
Concrete, per cu. ft.	429.00	316.90	.176	112.10	....	..
Painting	400.00	375.00	....	25.00	....	..
Steel footings and walls	300.00	218.91	....	81.09	....	..
Plant frt., etc.	1,860.00	2,271.73	....	....	411.73	..
Bond	100.00	120.00	....	....	20.00	..
Extras	77.80	67.97	....	9.83	....	..

FIG. 108.—Master card giving summary of cost.

the men it is very easy to make a correction, or if the efficiency varies, judgment must be applied to determine the correct rate to use. It has been the writer's experience that although the rate of wages and cost of materials vary somewhat in different parts of the country, the variations frequently offset one another so nearly that the sum total of the unit cost obtained in one place may be used in another, very seldom needing correction. For instance, within one month, after careful investigation, a bid was made up on a structure at San Juan, Porto Rico, using the same unit costs as for a building in Boston.

The following appeared originally in *Engineering-Contracting*, March, 1906:

We give here a full set of the record blanks used by the Aberthaw Construction Co., of Boston, builders of the Harvard "Stadium" and other reinforced concrete structures.

The Aberthaw Construction Co. requires its foremen to make daily reports on cards. The foreman has a time-book (printed especially for the Aberthaw Construction Co.), week ending Thursdays, leaving additional space sub-divided. This time-book is his original records which he copies on the daily report card. The foreman does not enter the rate of wages on the card; that is done in the office, the idea being to keep the clerical work of the foreman down to an absolute minimum. On large jobs the time-book is kept by a time-keeper; but with less than 20 men the foreman keeps the time.

The standard size of report card is 4 by 6 in. These cards are printed on heavy paper, which weighs about 160 lb. to the ream of 500 printed sheets, each sheet measuring 25 by 38 in. Cards of different are used to assist in rapid and certain classification. For example, the daily report cards, Fig. 109, are printed on yellow stock and on green stock. The yellow cards are used for the regular contract work, and the green cards for extra work. All the reproductions of the cards shown herewith are three-quarters the actual size.

The blank is printed on the back of the card just as on the front except that the Job No., Location, Date, etc., are not repeated. Hence on the face and back of the card there is room for the names of 27 men. It will be noted that this particular day's record related to concrete work, namely the building of a reinforced concrete fence. The number of bags of cement used in each class of work is recorded, opposite the corresponding number of "beams," "bases," "shafts," etc. On the back of the card is given the "Index" letter for each class of concrete work. For example, we see that the "Index" for "beams" is *BE*. We see, on the front of the card, that workman No. 3 worked 9 *BE*, that is, 9 hr., on beams. We also see that he was a carpenter, for his time is entered in the column for carpenters. We see that he was paid 30 cts. an hour. In the column headed Am't., is given a summary of the labor cost of all the carpenter work done on "beams" (*BE*), "shafts" (*S*), "bases" (*BA*), etc. In the similar column on the back of the

Job No. 370 Location Soldiers Field ABERTHAW CONSTRUCTION CO., BOSTON.
Date Sept. 20 1900 Daily Report

Name of Workman	Time	Time Carp.	Time Concrete	Time	Time	Rate	Am't	Put at head of proper column or against each name index of work performed.	
1 Thorne Foreman				10			$4.07	State each kind of work done. Amount of Cem. and Glass used.	
2 Henderson		3 C	6 C			0.30	C 0.90	Weather	
3 Jack		9 BE				"	BE 6.30 2.00	Temperature	
4 Finnion	9 S					"	S 5.40	Put in	Cement
5 Dunn	9 F					"	2.52	2 beams	18 bags
6 Davis		9 BE				2.00	BA 5.40 2.52	8 bases	15 "
7 Deboy		3 BE	6 S			0.30	2.70	2 Pile caps	9 "
8 Glover	9 S					0.28	F 2.00 3.30	55 ft. shaft	26 "
9 Sullivan		9 BE				0.30	C 1.80	6 shaft caps	6 "
10 McDonald		9 BA				0.28	1.33	Picked 3 bases	39 □'
11 Monroe		9 BA				0.30	S 1.80 2.25	" Shaft	414 □'
12 Murphy			9 S			0.25	4.00 4.80		
13 O'Leary			9 S			0.20	53.09	Approved	

YAWMAN & ERBE MFG. CO., ROCHESTER, N. Y.

Front of daily report.

Name of Workman	Time	Time Carp.	Time Concrete	Time	Time	Rate	Am't	Remarks	
14 Phelan			9 S			2.00	53.09 2.77	Work	Index
15 Ring				Clean S 9		1.65	PC 1.28	Beams	BE
16 McCue			9 F			"	BE 2.87 3.00	Bases	BA
17 Charly			10 PC			2.50		Shaft	S
18 Mahoney			4 PC	5 E	Pump 1	1.65	BA 2.11 5.70	Cap	C
19							0.22	Pile Caps	PC
20 P. McCarthy				10 E		2.00	PA 3.60 3.30	Foundations	F
21 Burgess			9 F			2.00	E 4.44 6.05	Picking Face	PA
22 Laughlin			9 F			1.65	Fill in 3.20 3.30	Excavate	E
23 Carley			Plaster 9			1.65	Clean S 1.65	General	G
24 No. 10			10½ BE			0.25	Wet pick 1.28		
25 " 98			6 C	1 PA	2 G	2.00	Plaster 2.00 1.20 1.65		
26 " 12			9½ BA			2.00	G 4.5 4.0		
27 " 13			9½ BA			0.20	3.95 107.51		

FIG. 109.—Back of daily report.

card is the summary of all day labor cost of the beams, shafts, etc.

In many kinds of contract work there is a certain amount of general work, which cannot be charged directly against any one item. This general work is given the Index letter *G*. There is often a certain amount of lost time, due to break-downs of plant, delay in receiving materials, etc., which it is well to charge against an item called Delays, indexed *D*. In this particular work of concreting on Soldiers' Field no such item is provided for, because the work was of such a character and so handled that delays were too brief to be worth recording. However, a contractor should always require his foreman to keep a record of every important delay, and assign a cause for it. This can be done very nicely by using index letters; thus, *DM* would indicate a delay waiting for materials; *DB* would indicate a delay due to a break-down of some part of the plant; and so on. If a break-down were to delay certain men in their work for an hour, then opposite their names would appear 1 *DB*, and 8 *BE*, for example.

Regarding the record of the quantity of work done each day, there is always a possibility of error. To reduce this error, the Aberthaw Construction Co. requires a supplementary report every Thursday, showing the total work of the week, and the condition of the job. In this way errors of estimated progress tend to balance up.

The foreman does not do the computing necessary to fill in the columns in Fig. 109 headed "Am't." This is done by the office force. All the foreman is required to do is to record the hours worked by each man, the class of work done by each man, the amount of cement used in each class of work, and the like. The office accountant knows just how many cubic feet or cubic yards of concrete are contained in each beam, each base, each shaft, etc.; and can compute the amount of work done by simple multiplication.

To quote from a letter by Leonard C. Wason, president and manager, Aberthaw Construction Co.:

"All the figuring up of pay rolls and summarizing of the weekly summaries is done by the office force, which takes two men about one day, and the bookkeeper a second day, each week, for all the work we have running. We have two comptometers for mechanical figuring, which saves vastly in the time

and energy of the clerical force. The item of cost of keeping these records is so infinitesimal that we have never attempted to separate it from the general office expenses."

The office force makes a weekly summary, compiled from the daily report cards. An example of such a summary is shown in Fig. 110, which is printed on a white card. This particular weekly summary gives the cost, in dollars and cents, of shafts, beams, bases, etc.

Job No. 370 WEEKLY SUMMARY Location Soldiers Field Fence.

From September 14, 1900 to Sept. 20, 1900

DATE	Fore.	CARP. Shaft	BE	BA	F	S	CONCRETE BE	C	BA	PC	F	PA	E etc.	G
Sept. 14	$3.67	7.92	7.40	7.92	5.16	16.15	8.43		5.80	4.70	9.55	7.05	17.74	12.08
" 15	3.67	5.22	9.20	7.92	6.78	16.15	11.50	5.22	5.02	5.62	7.20	5.25	12.15	14.95
" 17	4.07	7.92	15.50	5.22	7.19	12.05	8.90		2.00	7.63	9.55	4.65	13.81	14.65
" 18	2.85											0.55		1.48
" 19	4.08	5.22	12.80	5.22	8.00	9.85	8.55	5.15	5.34	4.25	3.02	5.80	14.21	13.50
" 20	4.07	8.82	8.30	7.92	8.00	12.85	5.87	3.13	7.81	4.05		7.12	16.99	12.58
	22.41	35.10	53.20	34.20	35.13	67.05	43.25	13.50	25.97	26.25	29.32	30.42	74.90	69.24

Kind of Work	Fore	Amt. Performed	Labor Cost per Unit	Cement Used	
Shaft	7.40	244 lin. ft.	$0.168	29 bbls	15 ft. per bbl.
Beams	4.71	20	2.40	45¾ "	2.29 bbls per Beam
Caps	1.34	24	0.62	6 "	0.25 " " Cap
Bases	2.91	35	0.825	15 "	0.43 " " Bases
Pile Caps	2.91	10	2.916	11½ "	1.15 " " Pile cap
Foundation	3.14	7	4.67	13½ "	1.93 " " foundation
PA		24.74	0.015		

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FIG. 110.—Weekly summary.

Figure 109 gives the time and cost of work done September 20, and it will be noted that the carpenter work on beams (*BE*) cost $6.30 plus $2, or $8.30; this $8.30 is entered in the weekly summary, opposite September 20 and in the column headed *BE*. In like manner all other summaries are entered in their respective columns, as shown in Fig. 110. The second column of this blank, headed "Fore," contains the daily wages paid to the foreman. The lower half of the card is devoted to a summary of the total number of units of work done and the labor cost per unit, exclusive of the carpenter labor, but inclusive of the foreman's wages. For example, the total labor cost of beams (*BE*) for the week was $43.25, and the percentage of the foreman's

wages charged to beams is \$4.71, making a total of \$47.96, or practically \$48, exclusive of carpenter's labor. Now, there were 20 beams built during the week, so that the labor cost was \$48 divided by 20, which is \$2.40 per beam. It will be seen that 45¾ barrels of cement were used in making these 20 beams, or 2.29 barrels per beam.

We have seen how the daily report card is filled in, and how the weekly report is made up in the office from the daily reports. We now come to the final report card, or the "master card of costs," as shown in Fig. 111. This card is printed on white stock, and its face and back are ruled as shown. The proposal price, the actual cost, and the profit or loss on each item, as well as on the total work, are entered on the face. Then, on the back of these cards, are entered the itemized unit costs, as illustrated.

It will be noted that all the cards are provided with a small circular hole in the lower center of the card. This is for filing the cards in the standard filing cases.

Figure 112 is the daily report made by the foreman, showing what materials have been received during the day, and what materials have been shipped away. On the front face of this card, as shown, are entered the quantities of different materials received. On the back face of this blank the entries are made of materials shipped away. This card is printed on blue stock for the regular contract work, and on green stock for extra work.

Even the ledger accounts are kept on cards, the cards for this purpose being Figs. 113 and 114. They are printed on white stock, and each card is printed on both front and back faces.

Figure 115 gives the expense account of each foreman or other employee who incurs expenses in behalf of the company. This blank is printed on the front face only, and on salmon-colored stock.

Figure 116 is a "pay order" card, and is printed on the front face only, on white stock.

Figure 117 is an "information wanted" card, and a carbon copy is kept by the man who fills out this card. This carbon copy is printed on thin paper, alternate leaves of the "information wanted" pad being printed on thin paper, so that a piece of carbon paper can be slipped between the thin paper and the card paper, thus giving a duplicate of all pencil writing. During the busy season the office force is out at different times, and the

Job No. 370
Date June 30, 1900 Fence Soldiers Field.

			Proposal		Actual Cost		per Unit	Result Profit		Loss		%
Total			27815									
Excavating			1115		883	26	c.f. .016	231	74			
Piles			1188									
Pile Caps			1351									
Foundations			2378									
Bases			1699									
Shaft			4038									
Beams			6896									
Caps			367									
Caps of Gate Posts			75									
Iron Railing			8708									

Front of master card.

Beams

	Cost	per beam		1900		
Carpenter	368.90	1.91	Work begun	7	9	194 Posts
Foreman	47.04	0.24	" finished	10	31	193 Beams
Concrete	448.26	2.32				
Picking	148.30	0.77				347 Piles
Generle	130.27	0.68				
Timekeeper	22.23	0.12				55,872 c.f. exc.
Cleaning	34.88	0.18				
Plastering	110.53	0.57				1455 lin. ft. Shaft
Cement	907.83	4.70				
Agg.	479.38	2.48				
Steel	439.98	2.28				
Lumber	209.53	1.09				
Team & Sunchies	291.55	1.51				
Profit						
		18.85				

Other Parts of work are figured in same manner

FIG. 111.—Back of master card.

Job No. MATERIALS RECEIVED ABERTHAW CONRTRUCTION CO., BOSTON.

Date 190 Foreman

SIZE OR BRAND	FROM WHOM RECEIVED	SIZE OR BRAND	FROM WHOM RECEIVED
bbls.	Cement	bbls.	Glass
bags	"	bars	Steel
lds.	Gravel	"	"
"	Sand	"	"
"	Screenings	"	"
lbs.	Cr. Stone	lbs.	Lampblack
"	"	"	Oakum
lds.	N. Sand	"	Nails
"	Ipswich Sand		
ft.	Lumber		

YAWMAN & ERBE MFG. CO., ROCHESTER, N. Y. [illegible]

FIG. 112.—Daily material report.

FORWARD FORWARD

Form [illegible]

FIG. 113.—Front of loose leaf ledger card.

Fig. 114.—Back of loose leaf ledger card.

ABERTHAW CONSTRUCTION CO., BOSTON.

EXPENSE ACCOUNT WEEK ENDING

Name				Name			
Day	Item	Amt.	Job	Day	Item	Amt.	Job

Approved

YAWMAN & ERBE MFG. CO., ROCHESTER, N. Y.

Fig. 115.—Expense account report.

Pay Order

ABERTHAW CONSTRUCTION CO.
7 Exchange Place, Boston, Room 52

Scratch out one { Original / Duplicate

Date The bearer

is entitled to dollars ($ 00)

in full payment for wages and expenses as per statement below.

Foreman.

Date	F	S	M	T	W	T	Total	Rate	Amount
Job No.									
Time									
Expenses									

Foreman will give every man discharged an order which will be cashed after Friday noon.

Mail duplicate to office immediately.

LIBRARY BUREAU A 46868

Fig. 116.—Pay order.

INFORMATION WANTED. **ABERTHAW CONST. CO., BOSTON**

Note Reply to the following inquiry on this card at the earliest possible moment and return to the writer. The writer will keep a carbon copy.

Date Mr. Re

Signed

Date Answer

Signed

LIBRARY BUREAU A46960

Fig. 117.—Information wanted.

Pattern No.	**Order No.**	**Cast Stone**	**ABERTHAW CONSTRUCTION CO., BOSTON.**
Article		**Date**	**Volume** **Cu. Ft.**
Remarks			

YAWMAN & ERBE MFG. CO., ROCHESTER, N. Y. 117419

FIG. 118.—Cast stone record.

Quotation Subject________________

7 Exchange Pl., Boston. Mass.________________

Messrs. ....

Dear Sirs :- Please quote hereon your lowest price f. o. b.________________
for the goods mentioned below and ***return this card to us*** and oblige,

Yours truly

ABERTHAW CONSTRUCTION CO

Per________________

Quantity	Article	List	Quotation

Sign here

FIG. 119.—Price quotation.

men may not meet one another for several days. These "information wanted" cards are then very useful. The carbon copy saves the need of remembering the question asked, and is used as a follow up if the reply is slow in coming.

We may note, in passing, that the use of carbon copies is becoming much more common than it once was. It not only saves the labor of copying a record, but in case of the loss of a record in the mails, or otherwise, the carbon copy is available. In many instances it is wise to keep all records in triplicate. This is easily done by having two thin sheets to each thick sheet, two pieces of carbon paper being used when filling in the blank.

PRICE LIST

Article

Date	Firm's Name		Price	Terms	Remarks

LIBRARY BUREAU, 37432

FIG. 120.—Record of prices quoted.

Figure 118 is an example of a triplicate record blank. One copy is kept at the shop, and the other two at the office. One of the office records is filed by serial number, and the other is filed by the subject of which the cost has been itemized.

When it is desired to secure a quotation on materials, machines or products of any kind, Fig. 119 is used. A carbon copy of this card is kept so that a firm which is slow in replying can be promptly followed up. This card is printed on blue stock, one side only.

Figure 120 is used for recording quotations on the same article as given by different firms. It is printed on salmon-colored stock, one side only.

A record is kept of every telephone message and every call message; separate sheets 4 by 5½ in. being used to record each message, giving time of day, name, telephone number, and message.

To many contractors of the old school, who have trained themselves to carry most of their business knowledge under their hats, it may seem that any system of recording facts and figures on cards or blanks is largely a waste of time. With this opinion we cannot agree. The very marked success of such firms as the Aberthaw Construction Co. is ascribed by their own officials as being due largely to the completeness of their cost keeping system. Leonard C. Watson, M. Am. Soc. C. E., the president of the Aberthaw Construction Co., has given us several specific examples of "leaks" discovered by virtue of his daily report records. Then, too, every employee feels that with such a system of daily reports, his output is bound to come under the eyes of the head of the firm. Each employee feels, consequently, that not only will laziness and inefficiency be discovered, but that merit will also be recognized and ultimately rewarded.

Cost Keeping on Rock Drill Work.—We give below some sample charts from *Engineering-Contracting,* Oct. 23, 1907, to be used in connection with the record cards to be found elsewhere in this book.

The charts show the location of the drill holes and the key letter that identifies the man who drilled them, as well as the depth of the hole in feet.

Two kinds of charts are shown, each adapted for a different class of work. Figure 121 shows a chart for use on railroads, canals and other engineering work that is laid out with a center line as a base for measurements. The ruling is the same as that for ordinary cross-section paper, used by engineers, each square representing a measurement of 2 ft. each way. Any one wishing to adopt this form can have it printed or can buy cross-section paper and make his own forms.

A work of explanation will show how this chart is used in connection with the form for recording explosives shown in Fig. 122. The work is being done on a new grade of a railroad in a cut that runs from Station 92 to Station 98, 600 ft. long. A stripping of 3 or 4 ft. of earth has been taken from the top of the cut by scrapers, leaving exposed a ledge of rock 12 to 15 ft.

deep to sub-grade, shown in cross section taken at Station 95 + 50 in Fig. 123.

The two short vertical lines in Fig. 123 running through the ground surface show the position of slope stakes set by the engineer. On these stakes are marked the cutting and the station number. Some engineers also mark on the stake the distance out from the center. If this is not done the contractor should have some one do so. With this distance known it will always

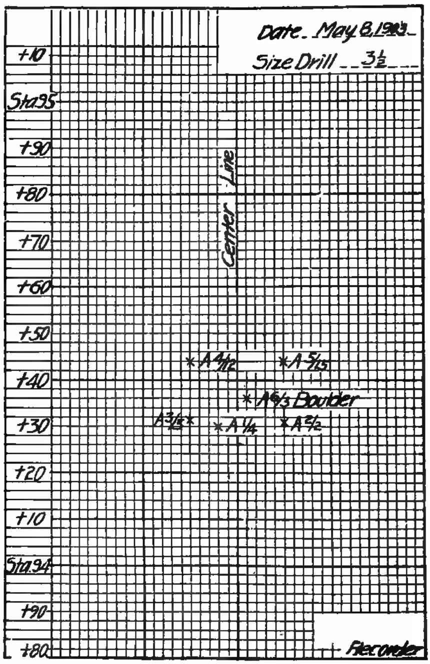


FIG. 121.—Chart for recording location of drill holes.

be possible to locate the center line, by measuring out from several slope stakes. For this purpose, as well as for other uses, very foreman should be provided with a metallic tape line. One of the authors has also provided his foreman with a half-dozen steel pins like those used by land surveyors. These pins can be made by any blacksmith, and should be about 10 in. long. Through the ring at the top a piece of red flannel should be tied so they can be easily seen and thus save them from being lost. The pins are not only useful in marking places on the ground,

but a foreman, by their aid, can make any measurement he desires, without assistance. He can stick a pin through the ring on his tape and make measurements without taking a man from his work to help him.

RECORD OF EXPLOSIVES USED May 8, 1903.

From Sta. No. 94+30 to Sta. No. 94+50. In Cut No. 95.

Hole No.	Depth Ft.	Springing					Blasting					Cu. Yds. Moved
		Dynamite Lbs.	Powder Lbs.	Judson Lbs.	Caps or Fuses	Fuse Ft.	Dynamite Lbs.	Powder Lbs.	Judson Lbs.	Caps or Fuses	Fuse Ft.	
A-1	4	1			1	5	8			1	5	
A-2	2						4			1	3	
A-3	5	3			2	10	12			1	6	
A-4	12	7	25		4	30	1		137½	1-14		245
A-5	15	23			1-3/14	22	1		162½	1-14		
A-6	3						3½			1	3	84
Totals		34	25		1-10/14	67	29½		300	2-4/14		249

Correct .... Foreman

FIG. 122.—Record of explosives.

In this way he can make his measurements on the ground to locate drill holes, and put them on the chart as shown in Fig. 121. In this case a driller, whose key letter is A, has been assigned to work in the cut in question. He starts by drilling a 4-ft. hole 4

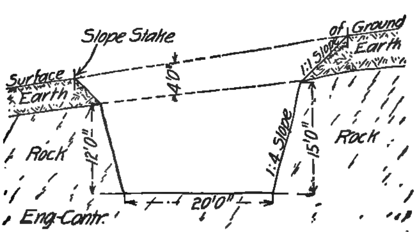


FIG. 123.

ft. to the left of the center line at Station 94 + 30. Then he drills a 2-ft. hole 10 ft on the right at + 31, following this with a 5-ft. hole 10 ft. on the left at the same station. These holes are drilled to "breast up" the cut at Station 94 + 32, and while these holes are being loaded and shot, and the muckers are

cleaning up the blasted material, two holes; are being drilled for a large blast: Hole No. 4 at 10 ft. on the left, 12 ft. deep; and hole No. 5, 10 ft. on the right, 15 ft. deep, at Station 94 + 44. After this blast is made a boulder is thrown in the way of the workers and the drill is set up to put a 3-ft. hole in it for blocking. This is hole No. 6, and notation is made on the chart to show that it was drilled in a boulder. This record can be made up by the foreman or timekeeper, from the pegs left in the holes by the driller, these pegs having burnt on them the driller's letter.

The blank filled out in Fig. 122 shows how these holes were shot, and gives a record of the explosives used. Hole No. 1 was sprung once with 2 sticks (1 lb.) of dynamite, and then shot with 8 lb. Hole No. 2 was not sprung but shot with 4 lb. of dynamite. Hole No. 3 was first sprung with 1 lb. of dynamite, and again sprung with 2 lb., being shot with 12 lb. All of these holes were exploded with cap and fuse, as the record shows.

Hole *A*-4 was sprung 4 times, first spring being with 1 lb. of dynamite, second with 2 lb, and the third spring with 4 lb. The fourth spring was made with one keg (25 lb.) of black powder. Powder was used to develop a seam that was opened up at the bottom of hole by the other springs. The springing of No. 5 was done with dynamite, four springs being made with respectively 1, 2, 6 and 14 lb. The last spring was shot with an electrical is exploder or fuse. The small amount of fuse used in springing caused by the fact that for the first springs only a piece of fuse 3 or 4 ft. long was used tied to a stick of dynamite, and after being lit it was dropped into the hole. This can be done when the hole is not ragged. These two holes were shot with Judson powder, the blasts being put off simultaneously with a battery. It will be noticed that the fuses used are recorded both as to number used and as to length.

Hole No. 6 in the boulder was shot with dynamite with a cap and fuse. The column for the yardage moved can be filled in by the superintendent or some one able to calculate the approximate quantity of rock loosened. No yardage is recorded with the first three blasts, as these blasts are chargeable against the yardage moved by the last heavy blast made in the cut.

A separate sheet which need not have the springing columns on, can be used for blasting boulders, and in a column for remarks can be noted the method used in breaking them up, such as "block-holing," "mud-capping" and other methods.

The blasts here recorded are not given as economical ones, but rather as examples of actual blasts, in which there is nearly always used more explosive than necessary to loosen the rock. Contractors prefer to shoot rock in this way, as it is extremely expensive to loosen and break up rock after an unsuccessful blast.

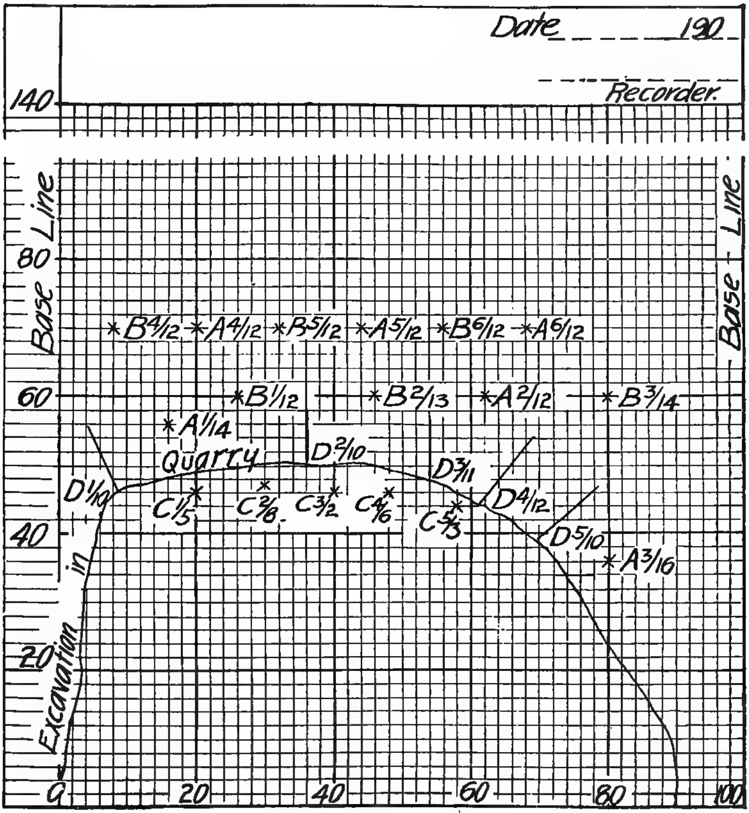


FIG. 124.—Chart of drill holes in a quarry.

The records shown on the chart and explosive sheet, should be copied upon permanent records in the contractor's office. The office chart, for showing location of the holes drilled, should be a long sheet of cross section paper, showing, on the same scale as the small chart, the entire line, except the embankments. The totals from the explosive sheet should be recorded in a

book made up for that purpose, which should also have columns for the drilling records, the work done by the muckers, and the transporting of the excavated material.

Figure 124 shows a chart to be used in a quarry. A base line can be run on each side of the excavation to be made in the quarry, and from these base lines any point in the quarry can be located, for recording on the chart. These records can be transferred to an office chart that can be on a larger scale, if desired.

From that chart shown here, it will be seen that four drills are working in the quarry. Drills *A* and *B* on top of the ledge of rock, and *C* and *D* down on the breast. *C* is a small drill putting down shallow holes, while *D* is a large drill snaking in holes on the breast as indicated by the long lines drawn from the face inward.

A sheet similar to the one illustrated in Fig. 122 can be used in a quarry to record the explosives used. An accurate estimate of the yardage may be difficult to obtain at times; but it is usually possible to approximate the yardage very closely by calculating the cross-section along each line of drill holes and the distance between the lines of holes.

In some tough rocks it is frequently necessary to drill a foot or two below grade, in order to be sure to break all the rock to grade. In such cases, due allowance should be made when estimating the yardage of "pay rock" broken. In other cases, the rock breaks one or more feet beyond the outer line of drill holes, and allowance for this should be made also. But, in any given kind of rock, the foreman or timekeeper will soon learn how much to allow for these factors, and can then estimate the yardage of "pay rock" accurately from the chart of drill holes. In this manner it is possible to make a very close report of the yardage of rock broken every day, without the necessity of cross-sectioning with an engineer's level. *The rock-drill does the cross-sectioning.*

Forms for Recording Well-drilling Costs.[1]—These forms are gotten up by the Cyclone Drill Co., of Orrville, Ohio, and are furnished to their customers for keeping records of drilling done by machines bought of them. The first blank illustrated in Fig. 125 is meant to record a day's work of well drilling or deep holes for blasting. From it the cost of drilling per foot

[1] *Engineering-Contracting*, Nov, 20, 1907.

REPORT OF CYCLONE DRILL.

No..................
For...Shift
....190....
Number of feet drilled..
Number of hours worked..
Driller..hrs....
Helper...hrs....
From........to..feet
....

Paid for coal.............. Paid for oil..............
Paid to move...................
....
....
....Driller

FIG. 125.—Report of well driller.

DAILY DRILLING REPORT.

Date..........................1905.
Contract No.....Hole No....Day of Week..........
For Whom..
Address...
Hole located near or at...............................

TIME RECORD.

	NAME	Began Work Hr.	Began Work Min.		Quit. Hr.	Quit. Min.	
Driller,	....	....	....	..M	....	....	..M
Helper,	....	....	....	..M	....	....	..M
Helper,	....	....	....	..M	....	....	..M
Machine,	Class.... No	....	....	..M	....	....	..M

DRILLING RECORD.

	Feet	Inches.
Depth last Report..................	......	......
Amount drilled today...............	......	......
Present depth of Hole..............	......	......

RECORDS OF DELAYS OR DIFFICULTIES.

....
....
....
....

MATERIAL RECORD.

Kinds of Core Barrel Used.	Length of Cutting Element, whether Barrel or Bit. Time Used Hr.	Time Used Min.	Before Ft.	Before In.	After. Ft.	After. In.
Standard............	......	......	....	....	....	....
Plain...............	......	......	....	....	....	....
Bit.................	......	......	....	....	....	....

Shot used pounds.........................
Anything used in place of shot. ......

EXPENSE RECORD.

Paid Whom.	For What.	Amount	
....	....	......	....
....	....	......	....
....	....	......	....
....	....	......	....

SUPPLIES NEEDED.—HOW TO BE SHIPPED.—WHERE.

....
....
....

RECORD OF DRILL HOLE.

Kind of Strata Drilled Today.	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
....	......	......	......	......
....	......	......	......	......
....	......	......	......	......
....	......	......	......	......

To the Treasurer: I vouch for the truth of this report.

Signed............................
P. O. Address.....................

FIG. 126.—Report of prospect drilling (Calyx core drill).

can be calculated, showing in detail the labor cost, coal and oil and cost of moving.

The form shown in Fig. 126 is meant to be used for prospecting drilling, especially where a core is taken for record. The form is printed on the two sides of the sheet. It gives a time record, depth drilled, record of delays, materials and bits used, expense account for the day and a record of the drill holes showing cores taken and the depth and thickness of the strata drilled.

A Report Card System for Dredging Work.[1]—In the June 13, 1907, issue of *Engineering News*, in an article descriptive of the Bush Terminal R. R. Co.'s dredge "Independent," mention was made of a report card system in use on that dredge and possessing features of some novelty. The system was devised by William H. Arnold, M. Am. Soc. C. E., who was prior to June 1, Chief Engineer of that company. J. A. Warner, General Superintendent of the company, furnished samples and data from which the following description was prepared.

The complete report cards are made up in there sections, perforations allowing the sections to be detached for use. Figures 127 and 128 show both sides of a complete card. All of the information required concerning the loading of a scow is printed on the card, and such information as applies to the loading of any one scow is indicated by a punch mark opposite such information.

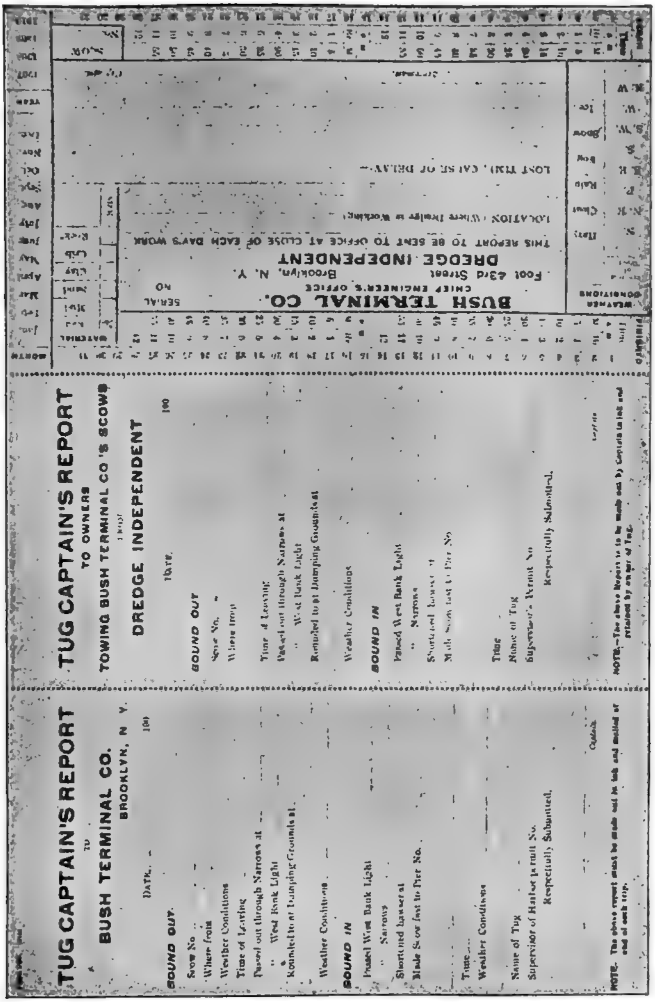
Figure 129 shows the portion of the card on which the punch records are made, as filled out. On this portion of the card, the serial number indicates the consecutive number of scows loaded; for example, the serial number 250, shown in Fig. 129, indicates that the scow covered by that report is the 250th scow loaded since the dredge began operation.

Provision is made to show the date, hour and minute at which the loading of the scow was begun and completed. The weather conditions, the kind of material handled, the location where the dredge worked, and any delays that may have occurred, are also provided for.

The amount of material loaded in the scow is indicated by a percentage system. In the sample card which has been filled out—see Fig. 129—the loading was 60% sand, 35% crib and 5% rock. The percentage, of course, is based on the carrying

[1] *Engineering News*, Aug. 22, 1907.

capacity of the scow, which in the case of the Bush Terminal R. R. Co. is 800 cu. yd.: hence, as indicated, 60% of the 800 cu. yd. was sand.


TUG CAPTAIN'S REPORT
TO
BUSH TERMINAL CO.
BROOKLYN, N. Y.
DATE 191
BOUND OUT
Scow No.
Where from
Weather Conditions
Time of Leaving
Passed out through Narrows at
West Bank Light
Rounded to at Dumping Grounds at
Weather Conditions
BOUND IN
Passed West Bank Light
Narrows
Shortened hawser at
Made Scow fast to Pier No.
Time
Weather Conditions
Name of Tug
Supervisor of Harbor permit No.
Respectfully Submitted,
Captain
NOTE. The above report must be made out at back and mailed at end of each trip.

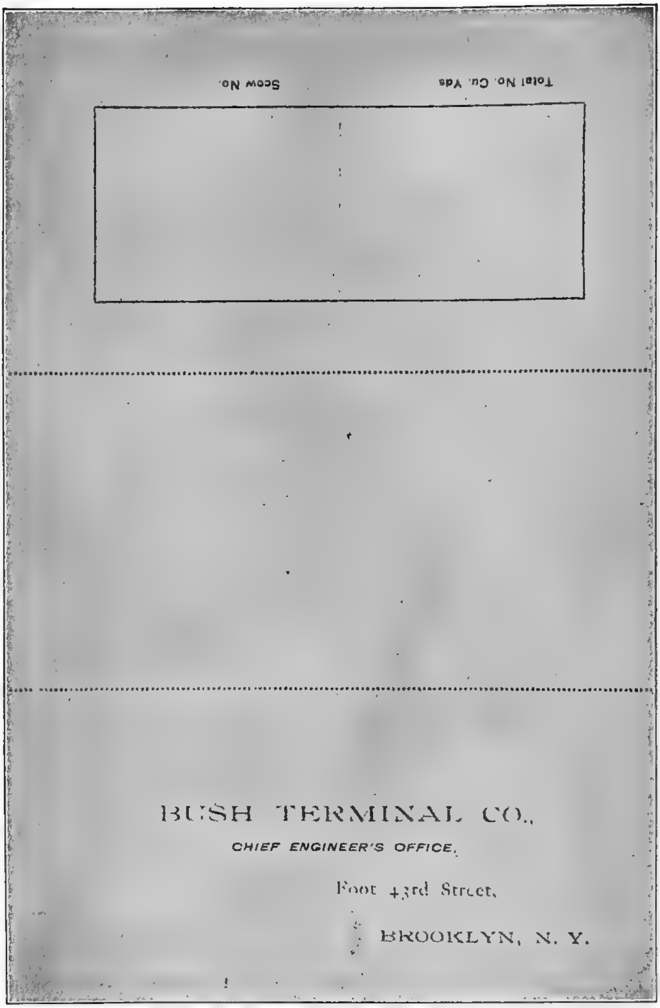
TUG CAPTAIN'S REPORT
TO OWNERS
TOWING BUSH TERMINAL CO'S SCOWS
FROM
DREDGE INDEPENDENT
DATE 191
BOUND OUT
Scow No.
Where from
Time of Leaving
Passed out through Narrows at
West Bank Light
Rounded to at Dumping Grounds at
Weather Conditions
BOUND IN
Passed West Bank Light
Narrows
Shortened hawser at
Made Scow fast to Pier No.
Time
Name of Tug
Supervisor's Permit No.
Respectfully Submitted,
Captain
NOTE.—The above Report is to be made out by Captain in ink and retained by owner of Tug.

BUSH TERMINAL CO.
CHIEF ENGINEER'S OFFICE
SERIAL NO.
Foot 43rd Street Brooklyn, N. Y.
DREDGE INDEPENDENT
THIS REPORT TO BE SENT TO OFFICE AT CLOSE OF EACH DAY'S WORK
LOCATION (Where Dredge is Working)
LOST TIME, CAUSE OF DELAY

FIG. 127.—Front of dredge tug report.

On the back of this portion of the card is a diagram representing the six pockets of the scow; this diagram is shown in Fig. 128. When this portion of the card is filled out, notations are made in each of the six spaces in this diagram, showing how many of the

pockets are full and how many partly full. Where the pockets are not filled, the shortage is indicated by the number of feet and tenths of feet that each pocket is short-filled; *i.e.*, if five of the


Scow No. Total No. Cu. Yds

BUSH TERMINAL CO.,
CHIEF ENGINEER'S OFFICE,
Foot 43rd Street,
BROOKLYN, N. Y.

FIG. 128.—Back of dredge tug report.

pockets were full and the sixth 0.5-ft. short-filled, the spaces representing the full pockets would contain the word "Full," and in the short-filled pocket would be made simply the notation

"0.5." In the case of an 800-cu. ft. scow, then, that would indicate that pocket No. 6 was filled to within 6 in. of the top of the coaming, and the total yardage for that scow would be 792.5.

The other two portions of the card, as shown in Fig. 127, are filled out by the captain of the tug which tows the scows to sea. They are given the same serial number as that given to the report of scows loaded. The addressed section is mailed to the Bush Terminal Co. and the unaddressed section sent to the owners of the tug towing the scow, for their information in rendering bills for towage.

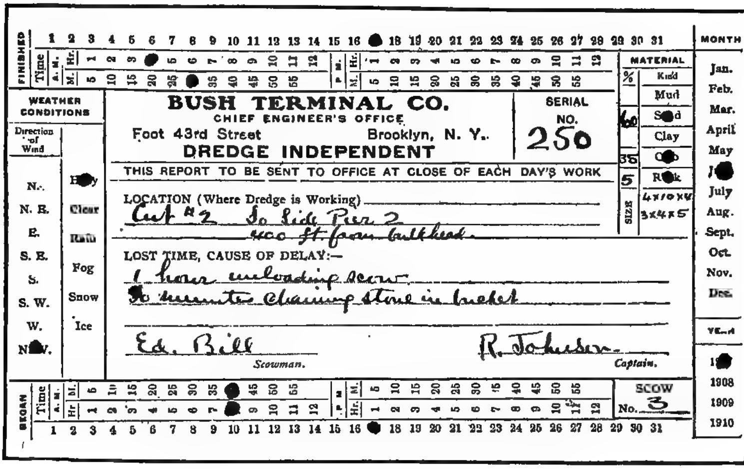


FIG. 129.—Dredge report (punch card).

The serial number of each scow is shown on the towing company's bill, thus enabling the towing company and the Bush Terminal Co. to agree without dispute upon the amount of any towing bill.

A System for Recording Costs of Dredging and Dredge Maintenance.[1]—The following, by Magee Fisher, is an article with blank forms describing a system which will appeal to many for its simplicity. It will be noted that this is more of a book-keeping than a cost-keeping system proper.

Accounts divide themselves into two classes: First, accounts of original entry, such as "time books" and "purchase books,"

[1] *Engineering-Contracting*, Aug. 14, 1907.

in which employes' time and purchases of various sorts are entered when made; and, secondly, accounts of final entry, to which are copied the items previously recorded in the books of original entry; the accounts of final entry are known as the "ledger." If the accounts of original entry can be so arranged that only footings have to be copied to the "ledger" an immense

No purchases to be entered on this page except those chargeable to
Cost and Maintenance of Dredge.
Purchases entered by John Smith.

Date 1905	Items.	Check Nos.	By Check.	In Curr'cy.	On Acc't.	Ledger Transfs.
Oct. 16	American Steel & Wire Co., cable........	201	$31.00			
17	Novelty Iron Works, bill to date.........	203	70.17			
17	From materials charged to Stock Acct. 2-7" x 16" x 32' timbers............					$30.00
20	Lamb Auto Co., acetylene lantern........			$20.00		
21	Nevine Hardware Co., Crosby clamps.....			2.50		
Total....	Week ending October 21, 1905...........		$101.17	$22.50		$30.00

No purchases to be entered on this page except those chargeable to
Operation of Dredge.
Purchases entered by John Smith.

Date 1905	Items.	Check Nos.	By Check.	In Curr'cy.	On Acc't.	Ledger Transfs.
Oct. 16	Nissen & Jacobson, 12 yds. oilcloth.......			$3.80		
18	Standard Oil Co., 5 gallons cylinder oil....			3.88		
18	E. N. Woodbury & Co., gaskets..........			.78		
20	Lamb Auto Co., acetylene................			2.00		
21	Smith & Sons, carload coal, No. 13347....				$78.40	
Total....	Week ending October 21, 1905..........			$10.46	$78.40	

FIG. 130.—Purchase book sheets.

amount of work and inaccuracy is thereby avoided. Such an arrangement is doubly profitable, for it obliges the accountant to decide beforehand just what accounts he will and will not keep; then, having decided, it is a very simple matter to make all the original entries chargeable to any given account on a page by themselves; then at the end of the week only the sum total of

the page need be copied to the ledger; and, if the loose-leaf system is used, all pages of original entry chargeable to that account, from the time book and purchase books, can be gathered together. But loose-leaf books have been a constant source of bother, the pages either tear out or some special kind of punching and paper have to be purchased. Fortunately, however, there have recently appeared for sale substantial clutch binders capable of holding unpunched paper of any kind and in such shape that the whole outfit may be handled as conveniently as a bound book.

Accounting is not an easy subject to write about intelligently, but the writer thinks that if any one interested will study the sample pages of accounts shown herewith he will be able to acquire the salient points. The illustration taken is the cost account of a dredging operation which the contractor not only wished to keep separate from his other operations going on at the same time, but to sub-divide so as to ascertain separately the cost of setting up, of operating and of maintaining the plant.

For this purpose he decided on two accounts as sufficient, one entitled "operation" and one "cost and maintenance."

First, in the "purchase book," Fig. 130, were entered all the purchases, which, for the benefit of the bookkeeper, were classified into "check," currency," "account" and "ledger transfer" purchases. Secondly, in the "time book," Fig. 131, were recorded the time of the employes, the state of the weather, the actual time operating, the progress of the work and other items of import. Then each week the sum totals were carried to the two ledger accounts, Figs. 132 and 133, where all functions of the work could be analyzed week by week. Observe the separate columns for each function—one for coal burnt, one for shifts worked, one for man-hours, one for cubic yards moved, one for labor cost and one for material cost.

The contractor's confidential bookkeeper also week by week posted off from the "time" and "purchase" books all cash items to his cash book and all "accounts" and "ledger transfers" to their proper places in the "ledger," thus completing a balanced or so-called "double entry" ledger.

Then when the work of dredging was finally finished the contractor abstracted the cost for future reference, Fig. 134, thus completing his record.

Many engineers might find it convenient to keep similar

No time to be entered on this page except that chargeable to

Operation of Dredge and Maintenance of same.

Time kept by John Smith. Week ending October 21, 1905.

Initial.	Name.	Charge to.	S.	M.	T.	W.	T.	F.	S.	Hours Operation	Hours Maintenance	Rate.	Amount Operation.	Amount Maintenance.
Roy	Long, foreman, night	Operation	5	10	10	10	10	10	15	70		30	$21.00	
Henry	Steffensen, foreman, day	Op.		10½	11½	11½	11½	11½	10½	67		30	20.10	
Burt	Shaw, engineer, day	Op.	10	10	11	11	11	11	10	74		20	14.80	
John	Scott, day	Maintenance			10	10	10	10	10		50	17½		$8.75
do	do	Maintenance	10	10						20		do	3.50	
Harry	Thompson, day	Op.		10½	10½	10½	10½	10½	9	61½		17½	10.76	
Arthur	Dawley, fireman, night	Op.		10½	10½	10½	10½	10½	9	61½		17½	10.76	
Harry	Breher, day	Maintenance			10	10	10	10	10		50	17½		8.75
do	do	Op.		10						10		do	1.75	
Ed	McCaul, day	Op.		10½	10½	10½	10½	10½	9	61½		17½	10.76	
James	Clarke, engineer, night	Op.		11½	11½	11½	11½	11½	11½	80½		30	24.30	
Ernest	Douglas, fireman, night	Op.		12½	12½	12½	12½	12½	14½	89		20	17.80	
J. W.	Duncan, night	Op.		11½	11½	11½		5½		51		17½	9.00	
										646	100		$145.53	$17.50
	Shifts			2	2	2	2	2	2	12				
	Hours actually running, day shift			4	9	5	8	8	7	41				
	Hours actually running, night shift			6	9	4	6	7	7	39				
	Day finished up No. 13347 and No. 768 cars coal			—	—	—	—	—	—	—				
	State of weather, day			Fair	Fair	Cloudy	Rainy	Fair	Fair					
	State of weather, night			Fair	Fair	Rainy	Fair	Cloudy	Fair					
	Cu. yds. earth moved			—	—	—	—	—	—	1200				

Fig. 131.—Time book, dredging.

cost abstracts of work valuable to them in a small card index, which would hold such records for a lifetime and yet never

Ledger for
Cost of Maintenance of Dredge. Page 2.
This account opened at commencement of Building of Dredge, June 15, 1905.

Date 1905.	Items.		Days to Build.	Man Hours.	Debits. Cost Labor.	Debits. Cost Supplies.	Credits
	Forwarded			1,951	$436.22	$913.57	
Oct. 21	Pay roll for week ending Oct. 21			100	17.50		
21	Purchases, by check					101.17	
21	do currency					22.50	
21	do ledger transfers					30.00	
Footing—week ending Oct. 21			30	2,051	$453.72	$1,067.24	

FIG. 132.—Ledger sheet.

Ledger for
Operation of Dredge. Page 3.
This account opened at commencement of operation, July 15, 1905.

Date 1905.	Items.	Tons of Coal.	Shifts Worked	Man Hours.	Cu. Yards Moved.	Debits. Cost. Labor.	Debits. Cost Supplies.
	Forwarded	58	144	10,085	13,781	$2,215.36	$1,209.15
Oct. 21	Pay roll for week Oct. 21		12	646	1,200	145.53	
21	Purchases, currency						10.46
21	do on acct						78.40
21	Cars of coal No. 13347—No. 768	32					
Footing—week ending Oct. 21		90	156	10,731	14,981	$2,360.89	$1,298.01

FIG. 133.—Ledger sheet.

(Abstract of Cost.)
Earthwork—Dredge Operation. 1905.

Location—Mississippi Valley.
Nature and extent—Railway embankment 2,000 feet long and 12 feet high; borrow pit along side and parallel with same.
Material—Sand and silt of Yankee River Delta.

Total yards moved	14,981
Shifts worked (ten-hour)	156
Cu. yards per shift	96
Total cost	$5179.86
Cost per yard—total	34.6c.
do. —operation wages	15.8
do. —operation coal	1.7
do. —operation repairs	7.0
do. —cost of plant wages	3.0
do. —cost of plant material	7.1
Pounds of coal burned	180,000
Pounds per yard moved	12
Average rate of wages per hour	22c.

FIG. 134.—Final abstract of cost, dredging.

be bulky. It seems as though printed matter and other records accumulate so fast that the average individual is completely "swamped" and gains no benefit from his records, whereas, if

the essential points were abstracted in compact form he could have them always at hand.

As illustrated above, the cost of any given piece of work is ascertained by adding together the various items, such as the cost of the labor, of the material, of the depreciation on the plant, of rent, of traveling expenses, etc. The amount of the work may be measured in units such as cubic yards of earth excavated, lineal feet of road built, or in per cents of completion, as in the case of a house where the architect specifies that it is 40% completed.

If the contractor has spent 50% of the money doing 40% of the work, he is apt to have the cold shivers. As frequently happens, he does not discover this until the facts have become ancient history.

This is one wrong way of cost keeping. He might better have not kept any accounts at all, for what good were they?

I have taken a house as an illustration, but many of my readers can bring to mind some railroad or other large undertaking that has come to grief from the same cause. Too much stress cannot be laid on the importance of entering all items of expense instanter and of keeping the accounts up to date.

Another wrong way of cost keeping is to keep too many cost accounts, the resulting work being so vast as to be a burden. Many persons fail to realize the amount of work involved in accounting; and this work is apt to be greatly increased unless the books are carefully checked and balanced at frequent intervals.

Estimating is almost the reverse of cost keeping. The work to be estimated is measured up into suitable units and tabulated. This is called "taking off." The estimated cost of each unit is then applied and the amount in dollars set out in the cost column. This is called "extending." This, then, is the engineer's estimated cost of the work to which the business department adds various amounts for overhead cost, profit, insurance against accidents, interest, etc. Many business men are said to add a liberal per cent for underestimating on the part of their engineer. Experience in paying the bills of underestimated work is a sure but costly road to accuracy in estimating.

Cost-keeping Blanks for Dredging.[1]—The port of Portland, Ore., has two hydraulic dredges at work deepening and widening the channel of the Columbia and Lower Willamette rivers.

[1] *Engineering-Contracting*, May 26, 1909.

One of these dredges has a capacity of 8,000 cu. yd. per day in sand, and the other has a daily capacity of 20,000 cu. yd.

THE PORT OF PORTLAND

LEVERMAN'S LOG

*Date*________________

*Dredge*________________ *Location*________________

*Shift No. 1*____________ *No. 2*____________ *No. 3*____________

Time	Gage	Bells	Depth	Width	Depth	Time and Cause Each Delay	Other Vessels Passed

Fig. 135.— Leverman's daily report, dredging.

The dredges work under the direction of the chief engineer of the Port, J. B. C. Lockwood, M. Am. Soc. C. E., and he uses

the following forms in keeping a record of the work done and in obtaining the costs.

In Fig. 135 is shown the blank for the leverman's report.

THE PORT OF PORTLAND

ENGINE ROOM LOG

Date __________

Dredge __________ *Location* __________

Shift No. 1 ________ *No. 2* ________ *No. 3* ________

Total running time

" lost "

Revolution counter No.

Blowed boilers at and at

" stacks " and at

Fuel received. Scow No.

Quantity on scow

Quality

Time and cause of delays in engine room

CHIEF ENGINEER

Fig. 136.—Engineer's daily report, dredge.

On this report the measurements are given from which the yardage dredged can be calculated. Also a record is kept of passing vessels and all delays to the dredge.

In Fig. 136 is shown the report of the chief engineer of the dredge. From this report the delays are taken so that it can be a check on the leverman's report. As to causes for delay,

THE PORT OF PORTLAND

CAPTAIN'S DAILY REPORT

Dredge ____________________

At ____________________

For 24 hours of ____________ ____________ *190*__

Character of material			
Length of pipe line			
Height of discharge			
Pontoon pipe in use. No.			
Shore " " " No.			
Moved ahead	Feet	Total for month	Feet
Depth dredged below zero			
Average width of cut			
" depth " "			
Yards excavated		Total for Month	
No. hours run		" " "	
Lost time		" " "	
Revolution counter		" " "	
Fuel received. Scow No.		" " "	
" quantity	Quality		
Rubber sleeves failed. No.'s			
" " installed. No.'s			
Hauled for vessels No.		Total for Month	
Other vessels passed No.		" " "	

CAPTAIN

FIG. 137.—Captain's daily report, dredging.

the leverman shows the reason for all causes other than those occurring in the engine room, the causes for the latter delays being given on the engineer's report. This report also shows

the amount of fuel used. The dredge for this work burn sawdust and shavings, the quantity being measured and estimated in cubic feet.

THE PORT OF PORTLAND No.______

ENGINEER'S MONTHLY REPORT

Dredge______________________________

At______________________________

For______________________ Inclusive______________190___

Character of material

Length of pipe line

Height of discharge

Pontoon pipe in use. No.

Shore pipe in use. No.

Moved ahead Feet. Average per day Feet

Depth dredged below zero

Average width of cut

Average depth of cut

Yards excavated Average per day Yards

No. hours run " " " Hours

Lost time " " " "

Revolution counter " " "

Fuel received. Scow No. " " " Load

Fuel, quantity Quality

Rubber sleeves failed. No's

Rubber sleeves installed. No's

Hauled for vessels. No. Average per day No.

Other vessels passed. No. " " " "

Total cost at $ per calendar day $

Cost per cubic yard cents

____
CHIEF ENGINEER

FIG. 138.—Engineer's monthly report, dredging.

In Fig. 137 is shown the blank used for the captain's report. The other reports are meant to show some details for each shift, there being three shifts of 8 hr. each, while in this report all the

work is grouped for the 24 hr. This report is evidently made from the two previous blanks and also from data collected by the captain, or under his direction.

In Fig. 138 is shown the cost analysis sheet, gotten up each month by the chief engineer of the Port. This form is at once a summary and also an analysis showing the cost per day, the cost per cubic yard, the average time worked per day, with average work done. This report is made up from the daily reports of the captain and also from the timekeepers' sheets or pay rolls. We regret that we cannot reproduce a copy of these forms. In all cases there should be blank forms, showing the number of men worked on each shift, their positions and rates of wages.

Special attention is also called to the analysis sheet, as this is a weak point in many cost-keeping systems; that is, the lack of an analysis sheet. From such a sheet it is possible, at any time, to learn of the efficiency of the work being done, and at the end of any job the average cost is quickly calculated. This is not possible when daily sheets only are kept, without a great deal of labor, and when a large number of daily reports have accumulated it frequently happens that it is never done. Thus the greatest value of cost keeping; namely, showing the efficiency of the work done, is not obtained.

A Cost Record System Used on Flood Protection Works at Grand Rapids, Mich.—The following system was described by C. S. Keating in a paper read before the Illinois Society of Engineers and Surveyors.

The administrative department of this work consisted of a superintendent and the writer. The former had charge of the men and of the direction and arrangement of the work. The writer had charge of the engineering and business portions. He had also the purchasing of all machinery, supplies, materials, fuel, etc.; looked after the various plants, keeping them in repair and good running order, and attended to the renting of all grounds, machinery, etc., and the direction of the teams.

The writer arranged and installed a cost account system. This included a general distribution sheet for the bookkeeper's use, cards for each division of the work (showing the amount of work done each day and the labor cost of same), and cards for recording minute observations for use in arranging men and teams to the best advantage. The writer kept the time per

FLOOD PREVENTION FUND

Date	Superintendence and General	Engineering		Coffer-Dam				Pumping								Quarrying Stone																							
				Construction		Maintenance		Plant			Operation					Plant																	Cleaning	Blasting				Moving	
								Cost	Installation		Labor	Coal	Oil & Waste	Repairs		Air Compressing								Drills & Piping								Tool, Carts, etc.		Labor	Material			Labor	Mat'l
		Labor	Car Fare	Labor	Mat'l	Labor	Mat'l		Labor	Mat'l				Labor	Mat'l	Cost	Installation		Operation					Cost	Installation		Operation								Dynamite	Fuses	Battery		
																	Labor	Mat'l	Labor	Coal	Oil & Waste	Repairs			Labor	Mat'l	Labor		Mat'l	Repairs									
																						Labor	Mat'l				Drilling	Sharp'g		Labor	Mat'l								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39

GRAND RAPIDS, MICH. 1905-6.

Crushing																		Wall																						Stone Sold		Totals
Plant								Operation										Excavation										Concrete														
Crusher			Engine			Bins		Engine					Crushing	(Moving to and Feeding)		Storage		Earth		Rock								Mixing				Concrete in Place					Rock Filling	Forms		Weighing	Hauling	
Cost	Installation		Cost	Installation		Labor	Mat'l	Labor	Coal	Oil & Waste	Repairs		Labor	Repairs		Labor	Mat'l	Labor	% Tools	Drilling			Blasting				Moving	Mixer			Labor	Labor	Material									
	Labor	Mat'l		Labor	Mat'l						Labor	Mat'l		Labor	Mat'l					% Comp'r	Labor & % Drills	% Tools	Labor	Materials				Cost	Install'n	Operat'n			Cement	Sand	Gravel	Blk's		Mat'l	Labor			
																								Dynamite	Fuses	Battery																
40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	

FIG. 139.—General distribution sheet.

sonally, so as to keep a more efficient account of the work and check up the distribution from the cards each night with the time for that day. He found that by keeping the time he became familiar with the face and dress of each man, and when watching the work, could readily tell the position of each man and the work he was doing. This was a great help where a large number of men were employed.

The cards used for this work were the ordinary blank filing cards, 8 by 5 in., and were ruled and marked by the writer as fast as they were needed.

The general distribution sheets were 38 by 24 in., ready ruled horizontally, and ruled vertically in the office to correspond to the various headings, as shown in Fig. 139. A tracing was made of the heading of the sheet and blue-prints made, which were carried by the city engineer and the writer to use for reference in writing orders for material, etc. One of these sheets was used by the bookkeeper and one by the writer. The bookkeeper's sheet was used for all accounts, and the writer's sheet for payrolls only. At the end of each week, the pay roll was totaled and checked with the distribution for that week, tabulated on the sheet, a list made out to correspond, and sent to the bookkeeper with the time book and tabulated on his sheet. Order blanks were used when buying materials, etc., and the distribution numbers put on each item. These were in duplicate, one going to the seller and the other to the office. In this manner the bookkeeper had no trouble in keeping his accounts correctly distributed.

Referring to the accompanying sketch of this general sheet (Fig. 139) under the heading of superintendence and general, was charged the superintendent's salary, carfare, cost of office, the lighting, watchman's time and part of the bookkeeper's time. To engineering was charged the writer's time and carfare, and the time and carfare of the field party giving lines, grades and taking cross-sections. The remaining headings are self-explanatory.

Taking the cards in sequence, to correspond to the general sheet, the first is the daily report of coffer-dam construction (Fig. 140). This example gives the card as it appeared for Feb. 22, 1906. No new sections were built or put in place, five sections were filled, making a total length of 80 ft. finished. Men filling: 4 at $1.75, 3 at $2; 4 teams at $5 hauling clay, and 3

men at $1.75 digging clay and loading. In connection with the heading "Men Placing" it may be explained that it took a number of men to bring the sections to place (which was done by the use of ropes), on account of the current in the river and the swirl around the end of the section already in place. The time for these men, which would be but a few minutes for each section, was kept by the foreman making note of the work from which each man was taken. In making up the distribution each

Daily Report of Coffer Dam Construction

Month of ____February________1906.

Days.	Sections Put In.	Sections Filled.	Length in Feet Finished	Men Building	Men Placing	Men Filling	Material				Men Digging Clay	Men Digging Sand
							Lumber	Clay Del.	Sand Del.	Bags		
Thur. 22nd	0	5	60	0	0	[illegible]		1 Team			3 @ [illegible]	

FIG. 140.—Daily report, coffer dam.

night, the time for placing was deducted from the work as indicated by the foreman's report. The bags used on this work were old grain sacks and were obtained from the various milling companies in the city at a cost averaging about $6.50 per 100.

The first example given on the "Pumping Record" (Fig. 141) is actual, the other is merely for illustration. The amounts of coal, oil and waste used were obtained by dividing the quantity received at that pump by the number of days run to exhaust the

Daily Record of Pumping.

Month of_February_ 1906.

Days	No. of Pumps	No. of Engines.	Rent of Pumps.	Rent of Engines.	No. of Engineers	Total Wages	Coal Lbs.	Oil Gals	Waste Lbs.	No. Hrs Run.	Pumping for	
											Wall.	Quarrying
Thur. 22nd	2 Hand	0	0		3-[illegible]	$5.25				10 Each	20 hours.	
	1 Cent.	1	50¢	$1.00	2 [illegible]	$5.00	500	[illegible]	[illegible]	24		24 hrs.

FIG. 141.—Daily report, pumping.

supply. The hand pumps were used for the wall only and the steam pumps for the quarry only.

The daily report of compressor operation (Fig. 142) is self-explanatory. The sections of "drills running" and "feet drilled" were used on this card for comparison. In the daily drill record card (Fig. 143) the operation of five drills necessitated the use of two cards to keep the record. The number of bits used for each drill, each day, was generally eight, there being four bits in a

set, and usually two sets were dulled in a day's running. The last column is to receive the wages paid the drill runner and helper.

Daily Report of Compressor Operation.
Month of February 1906.

Days.	Hours Run.	Steam Pressure	Air Pressure	Coal Lbs.	Nº of Drills Running	Feet Drilled	Oil Gals	Waste Lbs.	Repairs Labor	Engineers Salary

FIG. 142.—Daily report, air compressor.

The daily report of blasting was kept as shown in Fig. 144. The number of cubic feet displaced was measured on the surface,

Daily Drill Record.
Card Nº 1.
Month of February 1906.

Days.	Drill Nº 1.						Drill Nº 2.						Drill Nº 3.					
	Nº of Holes	Depth in Feet	Total Feet	Nº Bits Used	Hours Drilling	Operating Expense	Nº of Holes	Depth in Feet	Total Feet	Nº of Bits Used	Hours Drilling	Operating Expense	Nº of Holes	Depth in Feet	Total Feet	Nº Bits Used	Hours Drilling	Operating Expense

FIG. 143.—Daily report, rock drills.

and multiplied by the depth of the exposed face. The last three headings for lost time are for time lost in leaving the quarry

Daily Report of Blasting.
Month of February 1906.

Days.	Nº of Blasts.	Lbs. of 40% Dynamite	Nº of Caps	Nº of Feet of Hole.	Cu. Yds. Displaced	Labor Blasting	Lost drill time		Lost Labor time		Lost team time	
							Hrs.	Am't	Hrs	Am't	Hrs.	Am't
Thur 22nd	2	24	12	120	32	4 00	0	0	0	0	0	0

FIG. 144.—Daily report, blasting.

while blasting, but as most of the blasting was done at quitting time, noon and night, there was very little of this to account for.

Daily Report of Moving Stone.
Month of February 1906.

Days.	Teams Hauling to		Men Loading Wagons.	Men Unloading Wagons.	Men Loosening and Breaking.	Cu. Yds. Moved to		Total Cu. Yds.
	Storage	Crusher				Storage	Crusher.	

FIG. 145.—Daily report, hauling rock.

The report of moving stone needs no explanation further than the headings on the card, Fig. 145.

The blacksmith's report is shown in Fig. 146. As to the "drill bits sharpened," when the bits became too dull to do efficient work, they were heated, driven into a die and tempered. As to "upset and cut," after a bit had been sharpened a few times it became so small across the base as to bind in the hole, then it had to be upset, the leaves cut in and sharpened. The blacksmith made all the new bits needed.

Daily Report of Black-Smith.
Month of February 1906.

Days.	Hours Worked.	Nº of Drill Bits				Repairs to Drills.		Barrows Repaired	Picks & Bars Sharpen'd	Coal Lbs. Used	Wages.
		Sharpened	Upset & Cut	Made	Lbs. Steel	Labor	Mat'l.				

FIG. 146.—Daily report, blacksmith.

Daily Report of Crushing.
Month of February 1906.

Days.	Engineer	Coal. Lbs.	Oil. Gals.	Waste. Lbs.	Men Feeding	Cu. Yds. Crushed	Lost Time	
							Amount	Reason
Wed. 21st	[illegible]	340	½ Eng. ½ Cyl.	½	[illegible]	40	3 hrs.	Repairs.

FIG. 147.—Daily report, rock crushing.

Daily Report of Work on Wall.
Month of February 1906.

Days.	Bbls. of Cement.	Cu. Yds. of Sand.	Cu. Yds. of Stone	Men Mixing	Men Placing	Men Building Forms	Material Forms.	Material Placing	Nº Cu. Yds. in Place
Wed. 21st	26.5	9	21.5	[illegible]	[illegible]	[illegible]	[illegible] Ft. B. M.	[illegible] Ft. B. M.	21.5

FIG. 148.—Daily report, concrete wall.

On the crusher report, Fig. 147, the number of cubic yards crushed was obtained by tallying the number of yards in the bins, the amount hauled to storage, sold, and that used in the wall.

Minute Observations of Drilling.
Drill Nº.......... Kind.......................... Size..........
Runner.................. ....$ per hr. Helper.................. ....$ per hr.

Date	First Bit			Second Bit			Third Bit			Fourth Bit			Moving and Setting Up	Remarks.
	Change	Down	Pump	Change	Down	Pump	Change	Down	Pump	Change	Down	Pump		

FIG. 149.—Minute observations, drilling.

On the report of wall work, Fig. 148, the figures given are for illustration and are not actual. The amount of cement used was obtained by tallying the bags as they were used and checked by counting the empty bags at night. The lumber was measured in the forms each night by the writer. The concrete was measured in the forms and the work of each day lined out on the outside of the forms.

Minute Observations of Moving Stone.

Weather__________ Condition of Road__________

Length of Haul__________ to__________ Men______ $ per hr. Team______ $ per hr.

Date	Loading				Hauling	Unloading			Return to Load	Lost Team Time	No. of Yds. in Load	Cost per Yd. in cts.					Total Cost
	Size	No. of Men	Time	Total Time		No. of Men	Time	Total Time				Loading	Hauling	Unloading	Return	Lost Time	

FIG. 150.—Minute observations, hauling rock.

The "minute observations of drilling and moving stone" (Figs. 149 and 150) were made occasionally to get the most out of the drills. Also to get the best distribution of men for loading and unloading stone, so as to cut the time lost while the teams were standing to as small an amount as possible, while at the same time working the men to advantage. For example: When the number of men loading or unloading brought the price per cubic yard above the price of a preceding observation

Material Received and Accepted.

Week Ending Wednesday______1906.

Order No.	Date	Received from	Quantity	Items	Price	Amount	Distribution No.

FIG. 151.—Material received.

and the corresponding decrease in lost team time was not sufficient to balance it, it was evident that there were too many men loading or unloading and the force was decreased accordingly. The observations of drilling were taken to get the best results from the drills and keep the men from loafing when making new set-ups or changing bits.

Under the head of loading on the stone card (Fig. 150), the "size" gives the dimensions of the wagon box; the "time" is the number of minutes and seconds taken to load, and the "total

time" is the time multiplied by the number of men. "Hauling" is the time taken in going from the point of loading to the point of unloading and returning. The sud-headings under "unloading" are the same as for "loading." The number of yards in the load is taken from the size of the wagon box, and the cost is figured by dividing the total time multiplied by the rate of wages, by the number of yards in the load. The total cost will be the sum of the costs per yard multiplied by the number of yards.

The "material received" card (Fig. 151) was used merely as an additional check on the orders and to prevent any firm from charging up rejected material, and to keep a record of orders filled in part.

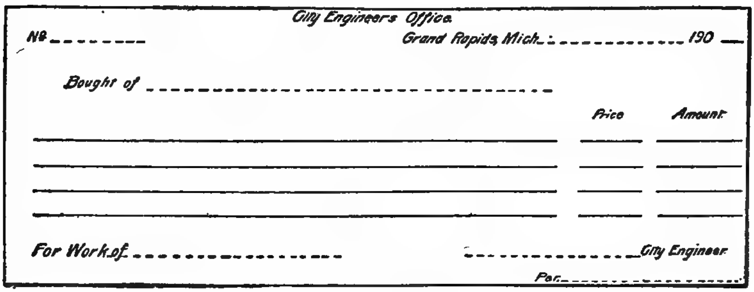

City Engineers Office
No.________ Grand Rapids Mich.______________190__
Bought of ____________________________________
Price Amount
For Work of ________________ ______________City Engineer
Per____________________

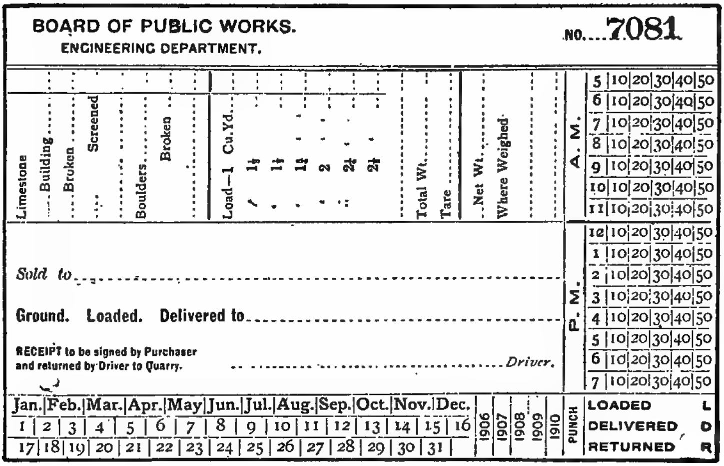
FIG. 152.—Order blank.

The order blank (Fig. 152) was used in general by the engineer's office when purchasing materials or supplies.

The stone slips (Fig. 153) were printed for this work and served the double purpose of a sales slip and tally on the time the teams were taking in making the deliveries. At the top is the kind of stone, the size of the wagon, the weights, and the scales used. Along the right-hand end are the hours from 5 A. M. to 7 P. M., and the minutes (by tens) for each hour. As the team was loaded, unloaded and returned the time was marked with the letter of indication shown at the bottom, in the minute square opposite the proper hour. At the bottom, the month, day and year are indicated by punching. The body of the slip is used for the purchaser's name, the place of delivery and the driver of the team. The words "ground" and "loaded" were used to designate respectively whether the stone sold was loaded from stone piled on the storage ground or loaded from the quarry.

From these cards and slips, taken together, the unit cost of any piece of work or any part of the work can be obtained. This is done by assembling the various items included in the work, from the card for that work and the items on the cards for any other division of work that may be chargeable to that work, in whole or in part.

For example: The cost of the crushed stone used in constructing the wall will be derived from the cost of crushing and quarrying. The quarrying in turn will include pumping, compressor operation, interest, depreciation and maintenance,


BOARD OF PUBLIC WORKS.
ENGINEERING DEPARTMENT.
NO. 7081

Limestone | Building | Broken | Screened | Boulders | Broken | Load—1 Cu.Yd. | 1¼ | 1⅓ | 1½ | 2 | 2¼ | 2½ | Total Wt. | Tare | Net Wt. | Where Weighed

A. M.
5 | 10 | 20 | 30 | 40 | 50
6 | 10 | 20 | 30 | 40 | 50
7 | 10 | 20 | 30 | 40 | 50
8 | 10 | 20 | 30 | 40 | 50
9 | 10 | 20 | 30 | 40 | 50
10 | 10 | 20 | 30 | 40 | 50
11 | 10 | 20 | 30 | 40 | 50

P. M.
12 | 10 | 20 | 30 | 40 | 50
1 | 10 | 20 | 30 | 40 | 50
2 | 10 | 20 | 30 | 40 | 50
3 | 10 | 20 | 30 | 40 | 50
4 | 10 | 20 | 30 | 40 | 50
5 | 10 | 20 | 30 | 40 | 50
6 | 10 | 20 | 30 | 40 | 50
7 | 10 | 20 | 30 | 40 | 50

Sold to ....

Ground. Loaded. Delivered to ....

RECEIPT to be signed by Purchaser and returned by Driver to Quarry. .... *Driver.*

Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec.
1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16
17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31
1906 | 1907 | 1908 | 1909 | 1910
PUNCH
LOADED L
DELIVERED D
RETURNED R

FIG. 153.—Stone record and team card.

drilling and moving stone, the blacksmith's work chargeable to drilling and tool repairs, the blasting, and the cost of cofferdam. The record of the number of men or teams or both, at work on any piece of work for each day, gives more concise data regarding the working conditions of the work, than would be the case if merely the total amount of time for the day were recorded.

By filing these cards, with a table for each showing the amount of work accomplished each day, together with the average cost per day, covering any convenient length of time or obtained after the completion of the work, excellent data would be kept for use in making estimates on work of the same character, making due allowance for the varying conditions.

Forms for Breakwater Construction, Including Quarrying, Concrete Work and Dredging.[1]—It should be stated that these blanks were not used by the contractors, but by the Government engineers who wished to secure a record for their own use. Now, it is obvious that a Government engineer is not particularly concerned about the daily output of each worker or each small group of workers, for it is not his province to devise a system that will make the men more efficient. In spite of this fact, these blanks have some good features that will serve as suggestions to contractors and to engineers who are doing similar work. Those who have written articles on cost keeping have usually been engineers, and not contractors. Hence they have had a point of view quite different from the point of view of the contractor. The engineer wants records of cost, principally to furnish assistance in estimating costs of similar work in the future. Incidentally, he wants records that can be used in case of claims for payment for extra work, and for use in presenting testimony in possible lawsuits between the contractor and the owner or company whom the engineer represents. The contractor, on the other hand, should keep cost records principally with a view to reducing his costs, and incidentally with a view to making safe bids on future work. Therefore, the contractor who says it does not pay to employ men to keep costs for him, simply exposes his own ignorance of what is the fundamental object of costkeeping.

Let us now consider the blank records used on the work of constructing the Buffalo Breakwater. This work involved the quarrying of rubble stone and capping stone for the breakwater; conveying this stone in scows from the Canadian quarry to the breakwater; placing the stone; making and placing concrete blocks for a superstructure; drilling and blasting out the channel in the harbor; and dredging the blasted material.

To obtain the cost of this work the Government engineers devised a set of daily report blanks, seven in number, which are reproduced herewith, two-thirds size. Each blank is 3½ times 8 in., which is a size convenient for filing.

Figure 154 gives the daily record at the quarry, including the force employed, the plant employed, and the output of stone shipped away. While this blank would serve well enough for the determination of costs at the end of the month,

[1] *Engineering-Contracting,* February, 1906.

it is of little use to a contractor, unless the stone that is quarried is shipped on the day that it is quarried. If not shipped on the same day, the record of daily output of the quarrymen cannot

BUFFALO BREAKWATER CONSTRUCTION

CONTRACT OF HUGHES BROS. & BANGS.

DAILY REPORT OF OPERATIONS

CANADIAN QUARRY.

....190......

RUBBLE STONE SHIPPED.

NO. OR NAME OF VESSEL	TONS.	NO. OR NAME OF VESSEL	TONS.

CAPPING STONE SHIPPED.

NO. OR NAME OF VESSEL	TONS.	NO. OR NAME OF VESSEL	TONS.

FORCE.	NO.	PLANT.	NO.
Superintendent		Locomotives	
Timekeeper		Large Flat Cars	
		Small Flat Cars	
Foreman		Dump Cars	
Drillers		Coal Cars	
Drill Helpers		Boxes or Skips	
Hoist Engineers		Stationary Boilers	
Firemen		Skeleton Hoist'g Engines	
Laborers		Hoist'g Engine with Boiler	
Engine Drivers		Incline Engine and Boiler	
Blacksmiths		Large Steam Drills	
Blacksmiths' Helpers		Medium Steam Drills	
Machinists		Pony Steam Drills	
Carpenters		Steam Pumps	
Water Boys		Derricks	
Watchmen			
Teams			

Remarks: Weather, Sea, Delays, etc.
Once a week measure each stone on one scow load of capping stone and note same in detail on back of report.

Inspector.

FIG. 154.—Daily report, quarry.

be determined from this blank. The stone was weighed by the water displacement of the scows, giving an accurate measurement of the total quarry output over any considerable period of time;

but, if asked, what was the exact output of the quarrymen on Tuesday of a certain week, no answer can be obtained from such a record. The record is, therefore, incomplete for the purposes

BUFFALO BREAKWATER CONSTRUCTION

Contract of Hughes Bros. & Bangs.

Daily Report of Operations Stone Breakwater

....190.....

DECK AND DUMP SCOWS.

RUBBLE STONE.

KIND OF STONE PLACED.	TONS	SEC.	RANGE. L.	RANGE. H.	BETWEEN STATIONS.
Small Rubble					
Ordinary Rubble ..					
Leveling					
TOTALS.					

NUMBER OR NAME OF VESSEL.

FORCE.	NO.	PLANT.	NO.

GRAVEL.

NO. OR NAME OF VESSEL.	CU. YDS.	SEC.	RANGE. L.	RANGE. H.	BETWEEN STATIONS.

FORCE.	NO.	PLANT.	NO.

Remarks: Weather, Sea, Delays, etc.

Inspector.

Fig. 155.—Daily report, breakwater.

of a contractor, although satisfactory for the purposes of the engineer.

Figure 156 on the other hand, is much more complete, for it

gives the daily output of the gang working on each derrick. Figures 157 and 158 for recording the concrete work, are also satisfactory. A contractor, however, would need a space for the name of the foreman in charge of each separate gang.

BUFFALO BREAKWATER CONSTRUCTION

Contract of Hughes Bros. & Bangs.

Daily Report of Operations Stone Breakwater

....190.....

DERRICK No...........

CAPPING STONE.

KIND OF STONE PLACED.	NO.	SEC.	RANGE.	BETWEEN STATIONS.
H. Footing Angle				
H. Revetment . .				
H. Capping . . .				
H. Top Angle . .				
L. Footing Course				
L. Revetment . .				
L. Capping . . .				
L. Top Angle . .				
Center Fillers . .				
TOTALS,				

RUBBLE STONE.

KIND OF STONE PLACED.	TONS.	SEC.	RANGE. L.	RANGE. H.	BETWEEN STATIONS.
Small Rubble . .					
Ordinary Rubble .					
TOTAL,					

FORCE.	NO.	PLANT.	NO.
Foreman		Derrick No.	
Hoist Enginemen . . .		Tugs	
Swing Enginemen . . .		Scow No.	
Asst. Foremen		Scow No.	
Stone Pickers			
Stone Setters			
Laborers			

Remarks: Report invariably the weather, wind and sea. Also delays, etc.,

Inspector.

FIG. 156.—Daily report, breakwater masonry.

Note especially that on Fig. 158 there is a column for entering the numbers of the stations between which the concrete was deposited. The stations were 100 ft. apart, as in railroad

work. This recording of the exact location of the work done each day is usually omitted by the contractor who has not had experience also as an engineer. It is a serious omission, for

BUFFALO BREAKWATER CONSTRUCTION

Contract of..

DAILY REPORT OF OPERATIONS

CONCRETE SUPERSTRUCTURE

....190.....

MANUFACTURE OF CONCRETE BLOCKS AT

KIND OF BLOCKS MADE.	NO.	MATERIALS USED.	NO.
Lake Face	....	Cement . . ..Bags.	....
Harbor Face	....	Broken Stone.........C.Yds.	....
Interior Wall	....	Gravel . . ..C.Yds.	....
Cross-Wall Parapet . . .	....	....	....
Cross-Wall Banquette . .	....	....	....
Special			
TOTALS,			

FORCE	NO.	PLANT	NO.
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

Remarks: Weather, Sea, Delays, Brand of Cement, etc.

Inspector.

FIG. 157.—Daily report, breakwater concrete.

the progress of all such work should be plotted on a map or profile kept in the office, so that the contractor can tell at a glance what work has been done each day, and where it has been done.

Coming now to Fig. 160, we find a blank that gives more detail than any of its predecessors. We note, for example, that each row of drill holes is numbered, and that each hole in

BUFFALO BREAKWATER CONSTRUCTION

Contract of..

DAILY REPORT OF OPERATIONS

CONCRETE SUPERSTRUCTURE

....190......

PLACING BLOCKS AND BUILDING SUPERSTRUCTURE AT

KIND OF BLOCKS SET.	NO.	SEC.	BETWEEN STATIONS.
Lake Face . .			
Harbor Face			
Interior Wall . .			
Cross-Wall Parapet . .			
Cross-Wall Banquette . .			
Special			
TOTAL,			

MASS CONCRETE PLACED.

LOCALITY.	[illegible]	CU. YDS.	
Lake Face Wall			
Banquette Deck			
Rem. Harbor Wall, etc.			
Parapet Deck			
Steps, etc. .			
TOTALS,			

MATERIALS USED.

Cement, Bags			
Broken Stone, Cu. Yds.			
Gravel, Cu. Yds			

FORCE	NO.	PLANT	NO.

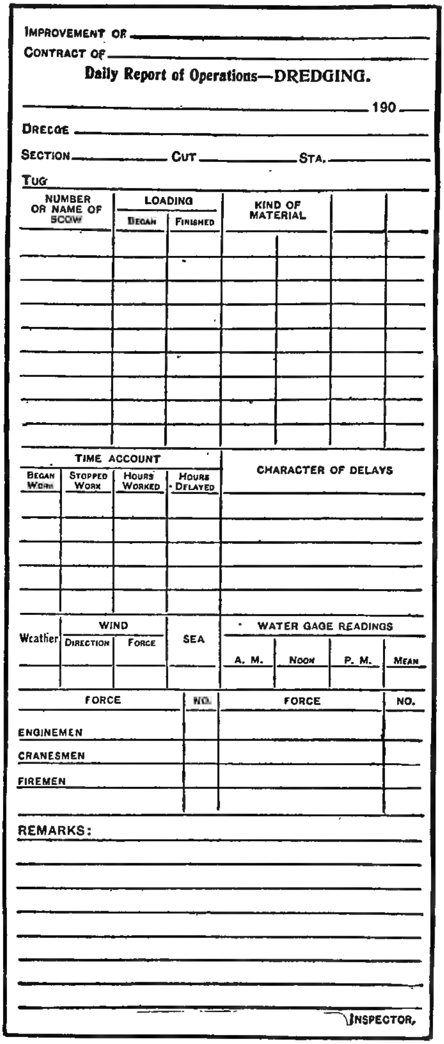
Remarks: Weather, Sea, Delays, Brand of Cement, etc.

Inspector.

FIG. 158.—Daily report, breakwater concrete.

the row also has its number. This, when accompanied by a sketch showing the spacing and position of the holes, gives an accurate record of the drilling work. The depth of each hole

is recorded and the number of pounds of dynamite charged in each hole. These holes were drilled under water, hence one column is reserved for entering the depth to rock.


IMPROVEMENT OF

CONTRACT OF

Daily Report of Operations—DREDGING.

190

DREDGE

SECTION CUT STA.

TUG

NUMBER OR NAME OF SCOW	LOADING		KIND OF MATERIAL			
	BEGAN	FINISHED				

TIME ACCOUNT				CHARACTER OF DELAYS
BEGAN WORK	STOPPED WORK	HOURS WORKED	HOURS DELAYED	

Weather	WIND		SEA	WATER GAGE READINGS			
	DIRECTION	FORCE		A. M.	NOON	P. M.	MEAN

FORCE	NO.	FORCE	NO.
ENGINEMEN			
CRANESMEN			
FIREMEN			

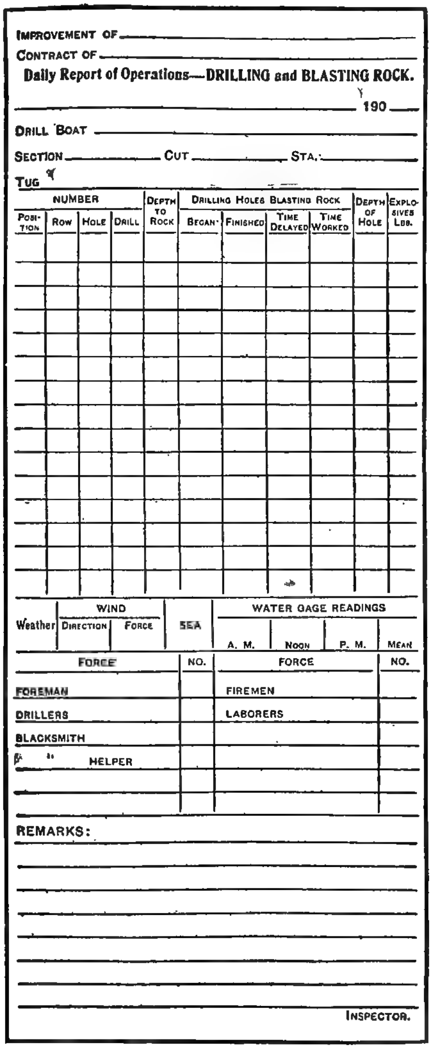
REMARKS:

INSPECTOR,

FIG. 159.—Daily report, dredging.

We are indebted to Emile Low, M. Am. Soc. C. E., for these blank reports, which were prepared by him while in charge of the Buffalo Breakwater construction. As a result of his experi-

ence with the keeping of records, he suggests that it would be wise to make the blanks 7 by 8½ in. in size, as indicated in Fig.



IMPROVEMENT OF

CONTRACT OF

Daily Report of Operations—DRILLING and BLASTING ROCK.

190

DRILL BOAT

SECTION CUT STA.

TUG

NUMBER				DEPTH TO ROCK	DRILLING HOLES BLASTING ROCK				DEPTH OF HOLE	EXPLOSIVES LBS.
POSITION	ROW	HOLE	DRILL		BEGAN	FINISHED	TIME DELAYED	TIME WORKED		

Weather	WIND		SEA	WATER GAGE READINGS			
	DIRECTION	FORCE		A. M.	NOON	P. M.	MEAN

FORCE	NO.	FORCE	NO.
FOREMAN		FIREMEN	
DRILLERS		LABORERS	
BLACKSMITH			
" " HELPER			

REMARKS:

INSPECTOR.

FIG. 160.—Daily report, subaqueous drilling.

160, which is the same as Fig. 154, except for certain changes in arrangement and certain additional columns. Figure 161 can be folded in the middle so as to form two pages of a note book,

BUFFALO BREAKWATER CONSTRUCTION.

CONTRACT OF HUGHES BROS. & BANGS.

DAILY REPORT OF OPERATIONS.

CANADIAN QUARRY.

....190....

FORCE. STATE OPPOSITE WHERE EMPLOYED.	Quarry.	Loading Dock.	Track.	Shops.		Total.	Rate.	Amount.
Superintendent.....								
Timekeeper.........								
....								
Foreman...........								
Drillers............								
Drill Helpers......								
Hoist Engineers....								
Firemen...........								
Laborers............								
Engine Drivers.....								
Blacksmiths........								
Blacksmiths' Helpers								
Machinists.........								
Carpenters.........								
Water Boys........								
Watchmen.........								
Teams.............								
....								
....								

Remarks: Weather, Sea, Delays, etc.
Once a week measure each stone on one scowload of capping stone and note same in detail on back of report.

RUBBLE STONE SHIPPED.

NO. OR NAME OF VESSEL.	TONS.	NO. OR NAME OF VESSEL.	TONS.
....	....	....	....
....	....	....	....

CAPPING STONE SHIPPED.

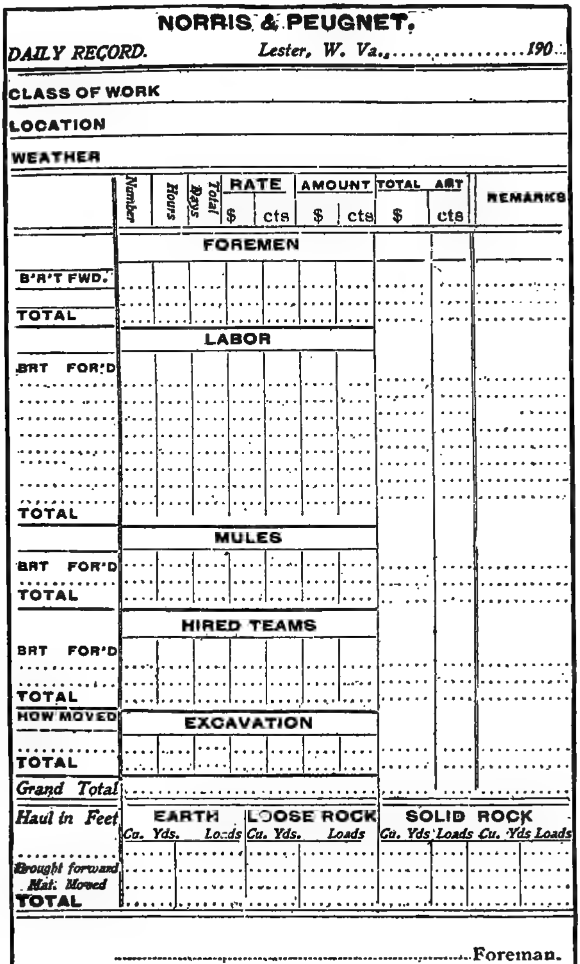
NO. OR NAME OF VESSEL.	TONS.	NO. OR NAME OF VESSEL.	TONS.
....	....	....	....
....	....	....	....

PLANT.

Locomotives...............		Large Steam Drills........	
Large Flat Cars...........		Medium Steam Drills.......	
Small Flat Cars...........		Pony Steam Drills.........	
Dump Cars...............		Steam Pumps..............	
Coal Cars................		Derricks..................	
Boxes or Skips...........		....	
Stationary Boilers........		....	
Skeleton Hoisting Engines..		....	
Hoisting Engine with Boiler		....	
Incline Engine with Boiler..			

FIG. 161.—Daily report, quarry.

each 4¼ by 7 in. Then the sheets can be made up into a time book containing 31 sheets, or one for each day in the month. However, if it were desired to send in the sheets each day, as


NORRIS & PEUGNET.

DAILY RECORD. Lester, W. Va., ...190..

CLASS OF WORK

LOCATION

WEATHER

	Number	Hours	Days	Total	RATE $	RATE cts	AMOUNT $	AMOUNT cts	TOTAL AM'T $	TOTAL AM'T cts	REMARKS
	FOREMEN										
B'R'T FWD.											
TOTAL											
	LABOR										
BRT FOR'D											
TOTAL											
	MULES										
BRT FOR'D											
TOTAL											
	HIRED TEAMS										
BRT FOR'D											
TOTAL											
HOW MOVED	EXCAVATION										
TOTAL											
Grand Total											

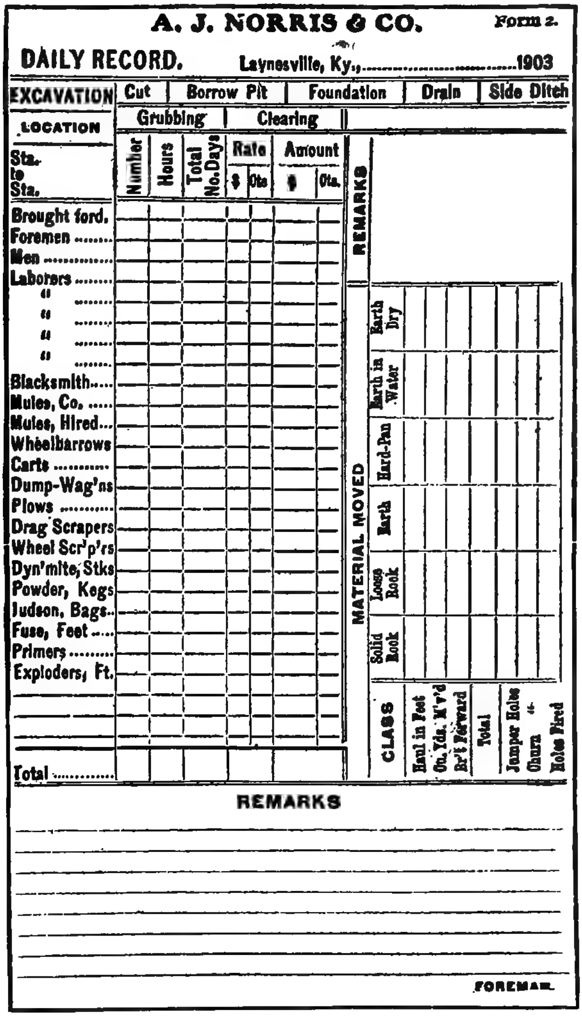
Haul in Feet	EARTH Cu. Yds.	EARTH Loads	LOOSE ROCK Cu. Yds.	LOOSE ROCK Loads	SOLID ROCK Cu. Yds	SOLID ROCK Loads	Cu. Yds	Loads
Brought forward								
Mat. Moved								
TOTAL								

................................Foreman.

FIG. 162.—Daily report, railroad grading.

would be the case where a contractor is keeping the records, the same sheets could be used and folded in the other direction making a folded sheet 3½ by 8½ in.

Cost Keeping on Railroad Construction.[1]—In railroad construction it is more difficult to secure proper supervision of workmen than on any other kinds of engineering work. This is due



A. J. NORRIS & CO. Form 2.

DAILY RECORD. Laynesville, Ky., ...1903

EXCAVATION | Cut | Borrow Pit | Foundation | Drain | Side Ditch

Grubbing | Clearing

LOCATION: Sta. to Sta.

Number | Hours | Total No. Days | Rate ($, Cts.) | Amount ($, Cts.) | REMARKS

Brought ford.
Foremen ....
Men ....
Laborers ....
" ....
" ....
" ....
" ....
Blacksmith.....
Mules, Co. .....
Mules, Hired...
Wheelbarrows
Carts ....
Dump-Wag'ns
Plows ....
Drag Scrapers
Wheel Scr'p'rs
Dyn'mite, Stks
Powder, Kegs
Judson, Bags..
Fuse, Feet .....
Primers ....
Exploders, Ft.

Total ....

MATERIAL MOVED: Earth Dry | Earth in Water | Hard-Pan | Earth | Loose Rock | Solid Rock

CLASS | Haul in Feet | Cu. Yds. M'v'd | Br't Forward | Total | Jumper Holes | " Churn | Holes Fired

REMARKS

FOREMAN.

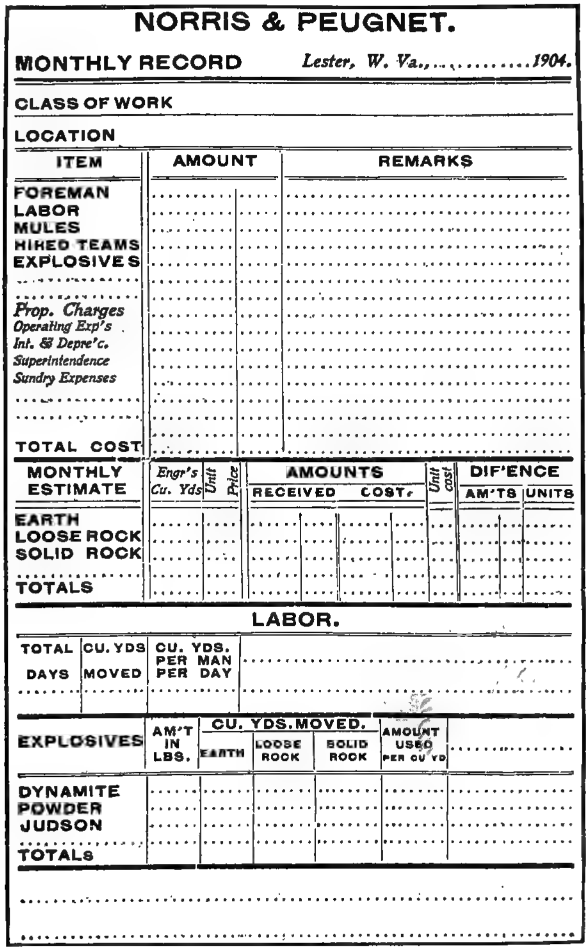
FIG. 163.—Daily report, railroad construction.

to the fact that the men are distributed along the line of the road, a contractor's forces being scattered over many miles.

[1] *Engineering-Contracting*, Sept. 25, 1907, and Nov. 6, 1907.

Under such circumstances the keeping of cost records of work done is essential to efficiency.

Figures 162 and 163 show two daily reports for open cut work. They both go somewhat into details, but No. 163 more so than



NORRIS & PEUGNET.

MONTHLY RECORD *Lester, W. Va.,..............1904.*

CLASS OF WORK

LOCATION

ITEM	AMOUNT		REMARKS
FOREMAN			
LABOR			
MULES			
HIRED TEAMS			
EXPLOSIVES			
....			
....			
Prop. Charges			
Operating Exp's			
Int. & Depre'c.			
Superintendence			
Sundry Expenses			
....			
....			
TOTAL COST			

MONTHLY ESTIMATE	*Engr's Cu. Yds*	*Unit*	*Price*	AMOUNTS RECEIVED		AMOUNTS COST		*Unit cost*	DIF'ENCE AM'TS		DIF'ENCE UNITS
EARTH											
LOOSE ROCK											
SOLID ROCK											
....											
TOTALS											

LABOR.

TOTAL DAYS	CU. YDS MOVED	CU. YDS. PER MAN PER DAY	

EXPLOSIVES	AM'T IN LBS.	CU. YDS. MOVED. EARTH	CU. YDS. MOVED. LOOSE ROCK	CU. YDS. MOVED. SOLID ROCK	AMOUNT USED PER CU YD	
DYNAMITE						
POWDER						
JUDSON						
....						
TOTALS						

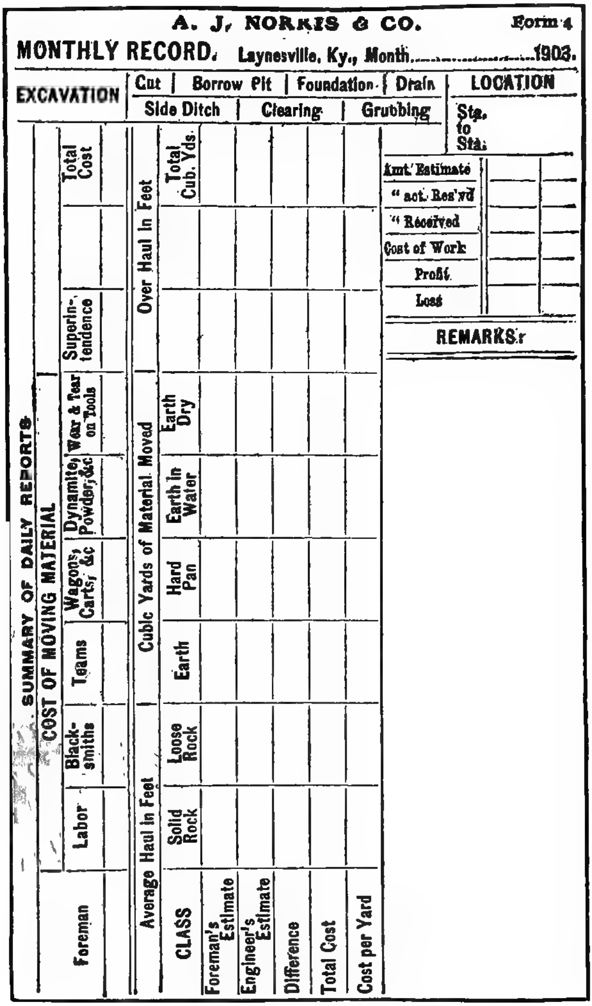
Fig. 164.—Monthly report, railroad grading.

No. 162. The latter has no spaces for explosives, blacksmith or feet of holes drilled, while No. 163 has spaces for these.

These reports are made out by each foreman for the gang working under him, and a contractor should have but little

trouble in judging quickly if any one gang is not being handled properly.

Figures 164 and 165 are blanks for making a monthly resume



A. J. NORRIS & CO. Form 4

MONTHLY RECORD. Laynesville, Ky., Month..................1903.

EXCAVATION | Cut | Borrow Pit | Foundation | Drain | Side Ditch | Clearing | Grubbing

LOCATION

Sta. to Sta.

Amt. Estimate

" act. Res'vd

" Received

Cost of Work

Profit

Loss

REMARKS:

SUMMARY OF DAILY REPORTS

Foreman

COST OF MOVING MATERIAL

Labor | Black-smiths | Teams | Wagons, Carts, &c | Dynamite, Powder, &c | Wear & Tear on Tools | Superin-tendence | Total Cost

Average Haul in Feet

Cubic Yards of Material Moved

Over Haul in Feet

CLASS | Solid Rock | Loose Rock | Earth | Hard Pan | Earth in Water | Earth Dry | Total Cub. Yds.

Foreman's Estimate

Engineer's Estimate

Difference

Total Cost

Cost per Yard

FIG. 165.—Monthly report, railroad construction.

of the daily reports. The value of the foreman's estimate of the amount of work done during the month on the form in Fig. 165 is questionable. It is the engineer's estimate that counts. The

DAILY LABOR REPORT.
NEW GALLITZIN TUNNEL,
PENNA. RAILROAD,
GALLITZIN, PA.

P. P. BRENDLINGER,
CONTRACTOR,
1009 Arcade Building,
PHILA., PA. DATE............190..

GENERAL FORCE.	$	Cts.
General Superintendent..........		
Tunnel Superintendent..........		
Ass't Tunnel Superintendent..........		
Chief Clerk..........		
Office..........		
TOTAL..........		

EXCAVATION—DAY SHIFT

West End.				East End.			
NO.	OCCUPATION.	RATE PER DAY.	AMOUNT.	NO.	OCCUPATION.	RATE PER DAY.	AMOUNT.
	HEADING.				HEADING.		
	Foremen				Foremen		
	Drill Runners				Drill Runners		
	Drill Helpers				Drill Helpers		
	Column Jackers				Column Jackers		
	Nippers				Nippers		
	Muck Foremen				Muck Foremen		
	Muckers				Muckers		
	Timber Foremen				Timber Foremen		
	Timbermen				Timber Men		
	Water Boy				Water Boy		
	Driver				Driver		
	Lampman				Lampman		
	BENCH.				BENCH.		
	Foremen				Foremen		
	Timber Men				Timber Men		
	Pitmen				Pitmen		
	Muckers				Muckers		
	Drivers				Drivers		
	Water Boy				Waterboy		
	Nipper				Nipper		
	Powdermen				Powdermen		
	Shovel Engineer				Shovel Engineer		
	Shovel Cranesman				Shovel Cranseman		
	Dinkey Runners				Dinkey Runners		
	Brakesmen				Brakesmen		
	Blacksmith				Blacksmith		
	Blacksmith Helper				Blacksmith Helper		
	Timekeepers				Timekeepers		
	Watchmen				Watchmen		
	Compressor Engineer				Compressor Engineer		
	Compressor Firemen				Compressor Firemen		
	Machinist				Mechanical Engineer		
	Stable Boss				Stable Boss		
	Drivers				Drivers		
	Hired Teams				Hired Teams		
	Carpenters				Carpenters		
	Carpenter's Helpers				Carpenter's Helpers		
	Dump Foremen				Dump Foremen		
	Dumpmen				Dumpmen		
	Crossing Watchmen				Crossing Watchmen		
	Drill Runners				Drill Runners		
	Drill Helpers				Drill Helpers		
	TOTAL				TOTAL		

MASONRY—DAY SHIFT.

West End.				East End.			
NO.	OCCUPATION.	RATE PER DAY.	AMOUNT.	NO.	OCCUPATION.	RATE PER DAY.	AMOUNT.
	RUBBLE SIDE WALLS.				RUBBLE SIDE WALLS.		
	Foremen				Foremen		
	Masons				Masons		
	Mason's Helpers				Mason's Helpers		
	Laborers				Laborers		
	Mortar Mixers				Mortar Mixers		
	Dinkey Runners				Dinkey Runners		
	Dinkey Brakemen				Dinkey Brakemen		
	TOTAL				TOTAL		
	CONCRETE.				CONCRETE.		
	Foremen				Foremen		
	Skilled Laborers				Skilled Laborers		
	Inside Laborers				Inside Laborers		
	Outside Laborers				Outside Laborers		
	Hoisting Engineers				Hoisting Engineers		
	Dinkey Runners				Dinkey Runners		
	Dinkey Brakemen				Dinkey Brakemen		
	TOTAL				TOTAL		
	PORTAL.				PORTAL.		
	Masonry Foremen				Masonry Foremen		
	Masons				Masons		
	Mason's Helpers				Mason's Helpers		
	Laborers				Laborers		
	Hoisting Engineers				Hoisting Engineers		
	Mortar Mixers				Mortar Mixers		
	TOTAL				TOTAL		
	DAY SHIFT.				DAY SHIFT.		
	Quarrying Stone				Quarrying Stone		
	Foremen				Foremen		
	Quarrymen				Quarrymen		
	Laborers				Laborers		
	Hired Teams				Hired Teams		
	TOTAL				TOTAL		

FIG. 166.—Daily report, tunneling.

foreman's estimate, even if made with sincerity, is more than apt to be influenced by his desire to get a large amount of work done, in order to make a good showing for himself.

These sheets are printed on manila cardboard and Figs. 163 and 165 are reproduced natural size, while Figs. 162 and 164 are slightly reduced. The first set was used on the Big Sandy extension of the Chesapeake and Ohio R. R., while the other set was for use on the Deepwater Ry.

Figures 166 and 167 are records of labor on tunnel construction only. The original sheet was 11 by 21½ in. The part reproduced shows day shift only, but on the original sheet by the side

RECAPITULATION.	$	Cts.
GENERAL FORCE.		
West End Tunnel { Day		
Night		
East End Tunnel { Day		
Night		
RUBBLE SIDE WALL.		
West End { Day		
Night		
East End { Day		
Night		
Portal Masonry { West End		
East End		
CONCRETE MASONRY.		
West End Tunnel { Day		
Night		
East End Tunnel { Day		
Night		
Quarrying Stone		
Floating Gangs		
Total		
Previous		
Total to Date		
Signed .... Chief Clerk.		

Fig. 167.—Daily report, tunneling.

of the day shift was a reproduction of the same form for a night shift, the only variation being that as the stone quarry was run during the day only, this did not appear in the night shift's report. The form is large and rather cumbersome and does not show details of progress of the work.

All these forms are subject to the criticism that the reports can not be made in duplicate on carbon copies. This is an important feature in cost keeping, for obvious reasons.

J. P. Hallihan, of El Paso, Tex., has described the following system which shows great care and ingenuity in its devising and includes some excellent forms.

While it is not always necessary that the engineer should have a complete cost-analysis, showing subdivision of cost per unit of measurement, it is required that the cost per unit in various locations, as in each cut, should be at his command, as well

as the manner of handling, disposition of material and time consumed.

Force reports in use in railroad work are not designed to secure this information, except in a very general way, usually giving a mere statement of force employed each day, without regard to costs.

The accompanying forms were used on some recent work in the Southwest, and were intended to collect all the data required in shape for condensation or further analysis, but the initial form was made as simple as possible, calling for no calculation on the part of foremen.

The field report (shown as Fig. 168) is bound in books of 35 duplicate sheets, colored white and yellow, the white sheet being perforated for removal. In the case of company work, the form is filled in duplicate, using carbon, then torn out and the information called for on reverse side (distribution of labor and foreman's estimate of material moved or work done) is filled in, carbon impression being taken on reverse side of sheet retained in book. The sheet is then delivered to the timekeeper, who checks the time given on report against the time which he has personally taken, and forwards report to the division engineer. On isolated jobs, or with small gangs where no timekeeper is employed, the report goes direct to general foreman or division engineer. At the end of the month all books are sent to office of division engineer, who is thus put in possession of the original record of each day's work.

Where the work is being done by a contractor, the data are obtained by force reporter using same form, omitting, of course, the names of employes and noting only the total number of each rate. The other information is obtained from foreman's statement, checked by personal observations.

Figure 169 is a condensation of daily reports into a weekly report, showing distribution of force on each section and total cost for period covered. Quantities moved may be closely approximated from daily reports and profiles and inserted in weekly report, if desired.

Accurate statement of quantities moved is, however, shown on the monthly sheet (Fig. 170) as derived from engineer's estimates. Figure 170 also shows total force and cost for month of work done on each section. It can also be arranged to show grand total cost of each section since commencement of work,

FOREMAN'S DAILY TIME REPORT.

Work done on sect.......... ....190...
By·..Foreman.
Between sta..and sta................................

Name.	Time.	Rate.	Name.	Time.	Rate.
....	....	....	....	....	....
....	....	....	....	....	....
Teams:					
..................4-plow....	....	....	..................Supply....	....	....
..................6-plow....	....	....	..................Cart......	....	....
..................8-plow....	....	....	..................Stone boat.	....	....
..................Slip......	....	....	..................Wagon....	....	....
..................Fresno....	....	....	..................Car......	....	....
..................Wheeler..	....	....	..................Water....	....	....
..................Snatch....	....	....	..................In corral..	....	....

Material Used.

Pounds of Dynamite.	Kegs Black Powder.	Feet of Fuse.	Number of Caps.	No. and length of Exploders.	Sacks of Cement.	Liters Black Oil.	Liters Cy'l Oil.	
....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....

Class of work:

Clearing. Excavation. Earth. Loose rock. Solid rock.
Borrow. Waste. Haul....................Meters.
Tunnel No,.............................. Structure No..............
Cross out words not necessary to express nature of work.

(OVER)

Distribution of Labor.

No.	Employe.	Time.	Rate.	
....	Foreman....................	....	....	....
....	Sub-Foreman....................	....	....	....
....	Laborers....................	....	....	....
....	Drillers....................	....	....	....
....	Nippers....................	....	....	....
....	Water boys....................	....	....	....
....	Blacksmiths....................	....	....	....
....	Blacksmith Helpers....................	....	....	....
....	Drivers....................	....	....	....
....	Corral men....................	....	....	....
....	Bridgemen....................	....	....	....
....	Timbermen....................	....	....	....
....	....	....	....	....
	Miscellaneous: Work done, etc....................	....	....	....
....		....	....	....
....		....	....	....
....		....	....	....
....		....	....	....
....		....	....	....

....Foreman.

Foreman will fill this blank out daily and forward to timekeeper.

Fig. 168.—Daily report, railroad grading.

FERROCARRIL, RIO GRANDE, SIERRA MADRE Y PACIFICO

....................FORCE REPORT—GRADING.

Contractor..........................Division No............Section Nos............Station...............To Station................190...

Date.	Section.	Stations.	Clearing & Grubbing.		Excavation and Borrow.																			Material Used.					Costs.				Remarks.
												Teams.																					
																			Plow.														
			Foreman.	Laborers.	Foremen.	Laborers.	Drillers.	Nippers.	Water boys.	Blacksmiths.	Blacksmith Helpers.	Carts.	Stone Boat.	Slip.	Fresno.	Wheeler.	Snatch.	Supply.	Water.	4	6	8	In Corral.	Total.	Dynamite, Lbs.	Black Powder, Kegs.	Fuse—Feet.	Caps—No.	Exploders No. and Length.	Labor.	Material.	Camp and Miscellaneous.	Total.	
To-tals @ Cost																																		

NOTE.—Under Camp Costs show fixed cost of Camp, which consists of General Foreman, Timekeeper, Corralman, Cook—all fixed employes of camp except Commissary Clerk, who is chargeable to Commissary.

Checked: .... Const. Eng.

Correct: .... Line Rider.

FIG. 169.—Weekly report, railroad construction.

Report of Clearing, Grubbing and Grading During ______________ 190___

SECTION	STATIONS	CLEARING & GRUBBING							GRADING												
		FORCE		COST					FORCE				COST				Total Engineers Estimate To Date	QUANITY MOVED			
		No. Men	No Teams	Labor	Material & Misc'l.	Total	Total to Date	Engin'r's Estimate to date	No. Men	No. Teams	Graders	Steam Shovels	Labor	Material & Misc'l	Total	Total to date		Earth	Loose Rock	Solid Rock	Haul

FIG. 170.—Monthly report, railroad construction.

and, for the use of a general contractor, this would obviously be required.

The daily report form is used for all classes of work, the weekly and monthly reports being printed to conform to nature of work and information required.

Cost-keeping System of Fred T. Ley & Co., Inc., of Springfield, Mass.[1]—We take up the system of Fred T. Ley & Co., who, as will be seen at the close of this article, have built many miles of electric railways, conduits, etc. The editor visited one line of railway work being done by this company some years ago and found that a very careful system of cost keeping was in use. Since the visit of the editor, the company has developed and improved its system, and, like all other firms of contractors who have once perfected a cost-keeping system, nothing could induce them to adopt the guesswork plan of cost keeping.

Before describing the record blanks used by Fred T. Ley & Co., it is well to point out that their work has often been of a kind most difficult to keep track of. Frequently it has been strung out over 20 miles on one contract. Now, it is obvious that a system which is designed for use on work that is concentrated within a limited area may need decided modifications when applied to scattered work. The features of the Ley system can best be understood from a brief description of the record blanks and their use.

The timekeeper takes the time of each gang on Blank No. 1*a* (Fig. 171). He uses a separate sheet for each separate gang of men. He puts down each man's number, the hours worked and the rate per hour. One sheet holds the names of 30 men besides 14 teams. These sheets are bound in a loose-leaf binder, as indicated by the holes. On the reverse side of each sheet is Blank No. 1*b* (Fig. 172), which is filled in so as to give the total cost of the day's work of the gang, the amount of work done, the location of the work, and the haul. In this case the work was located between Stations 1 and 8; the haul was 500 ft., and the output was 200 loads of gravel, at a cost of $41.48. Thus we have the cost of the work done March 15, on the cut between Stations 1 and 8.

On every large job there are many general expenses that must be distributed over a number of gangs of men; for example, the salaries of superintendent, timekeeper, etc. These miscel-

[1] *Engineering-Contracting*, April, 1906.

TIME SLIP

W. C. CONTRACT

Mar. 15 1905

NUMBER	HOURS	RATE	NUMBER	HOURS	RATE
700	10	15			
702	"	"			
705	"	"			
709	"	"			
724	"	"			
813	"	"			
825	"	"			
846	"	"			
872	"	"			
925	"	"			
976	"	"			
854	"	"			

TEAMS	HOURS	RATE	TEAMS	HOURS	RATE
Jones	10	45			
"	"	"			
Smith	"	"			
"	"	"			

MISCELLANEOUS

Fig. 171.—Front of timekeeper's sheet.

FRED T. LEY & CO., Contractors.

Mar. 15 1905

Sta. 1 to 8 Haul 500'

FOREMAN Clark

MEN	HOURS	RATE		COST	
				3	
12	120	15		18	
TEAMS	HOURS	RATE			
4	40	45		18	

MISCELLANEOUS

MISC.	2	48
TOTAL	41	48

MATERIAL Gravel

AMOUNT OF WORK 200 loads

REMARKS

WEATHER

FAIR

Fig. 172.—Back of timekeeper's sheet.

laneous charges are entered on a "miscellaneous sheet" like Fig. 171, and the total is divided up among the different pieces of work, pro rata. Thus, Fig. 172 shows that $2.48 was charged from the miscellaneous sheet.

DAILY REPORT.

Contract No.................... ....Contract.

.... 190 ....Section.

HELP EMPLOYED.

No.	FOREMEN				No.		LABORERS				
	Foremen @	per hr.	hrs.				Men @	per hr.	hrs.		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				Total,				
	Total,						MISCELLANEOUS				
	TEAMS						@	per hr.	hrs.		
	Teams @	per hr.	hrs.				@	"	"		
	"	"	"				@	"	"		
	"	"	"				@	"	"		
	"	"	"				@	"	"		
	"	"	"				@	"			
	"	"	"				@	"	"		
	"	"	"				@	"	"		
							Total,				
							Total Pay Roll,				

....Time Keeper.

FIG. 173.—Timekeeper's daily report.

On large contracts, the timekeepers make out a daily report, Blank No. 2 (Fig. 173), which gives the total expense each day of the entire contract; and the total of the small detail sheets (Blank No. 1*b*) must agree with the total of this large sheet.

When the timekeeper takes his time in the morning, he gets from each foreman a supply report filled in on Blank No. 3 (Fig. 174). This gives the amount of material used the day before on each particular kind of work. The timekeeper sends in these supply reports with his daily time slips.

When the reports are received in the office, they are first turned over to the pay-roll clerk, who tabulates the time. When he is through with them he turns them over to the record clerk, who records them on the proper sheets. When the pay roll is made up every 2 weeks, its totals must agree with the totals on the time slips.

STATION.					............190.			
SUPPLY SHEET.			GIVE THIS SHEET TO THE TIMEKEEPER EACH DAY.					
SUPPLIES	GRADING	ROCK	CONCRETE	RUBBLE	PIPE LAYING	TRACK	BALLAST	CEMENT BAGS RETURNED
DYNAMITE								
EXPLODERS								
POWDER								
CAPS								
FUSE								
CYL. OIL								
BLACK OIL								
WASTE								
CEMENT								
STONE								
LUMBER								
				FOREMAN.				

FIG. 174.—Daily supply report.

A summary of the time slips (Fig. 172) is entered on Blanks Nos. 4, 5 and 6 (Figs. 175, 176, 177), a separate blank being used for each cut and for each separate gang of men. Thus, Fig. 175 shows the cost of excavating and filling between Stations 1 to 8, by days beginning with March 15. We see that the total number of loads was 200, and that the cost per load was $0.207. There is room to enter 29 days' work on the front side of each of these blanks, and as many more on the rear side. At a glance it can be seen what each day's work has cost per load, and the contractor is in a position to detect any increase or decrease in the cost, from day to day. This enables him to discover inefficiencies in men or methods—not weeks after the work is done, but the day after.

Figure 176 is essentially the same as Fig. 175, excepting that

GRADING Cut from Sta. 1 to 4 Fill from Sta. 4 to 8

DATE	FOREMAN	STATION			MATERIAL	MEN			TEAMS			MISC.	TOTAL	NO.	COST	REMARKS
		CUT	FILL	HAUL		HRS.	RT	COST	HRS.	RT	COST	EXP.	COST	LDS.	LD	
Mar. 15	Clark	2'	7'	500'	Gravel	120	15	1800	40	45	1800	548	4148	200	207	

Fig. 175.—Summary sheet, grading Sta. 1 to 8.

ROCK

DATE	FOREMAN	STATION			MEN			TEAMS			MISC.	TOTAL	DYN.	EXP	FEET	NO.	DRILL'G LD.	REMARKS
		C	F	H	HRS	RT	COST	HRS	RT	COST	COST	COST	USED	USED	DRILLED	LDS	COST	

Fig. 176.—Summary sheet, grading.

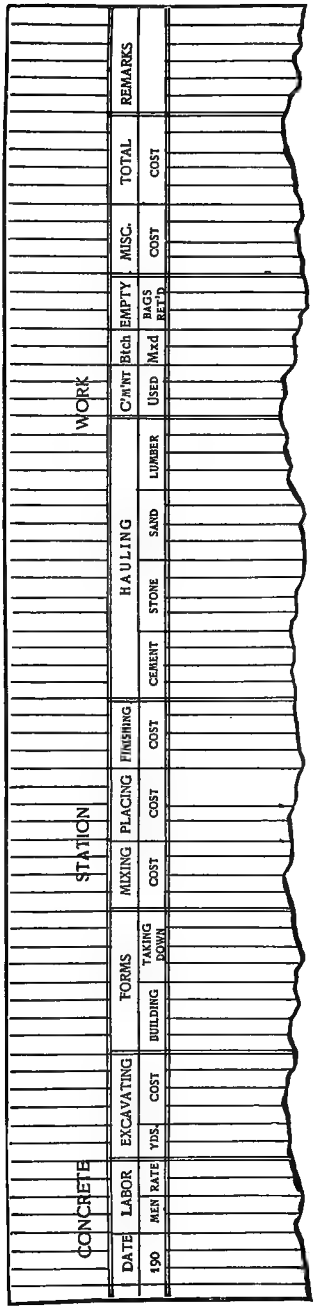


FIG. 177.—Summary sheet, concrete.

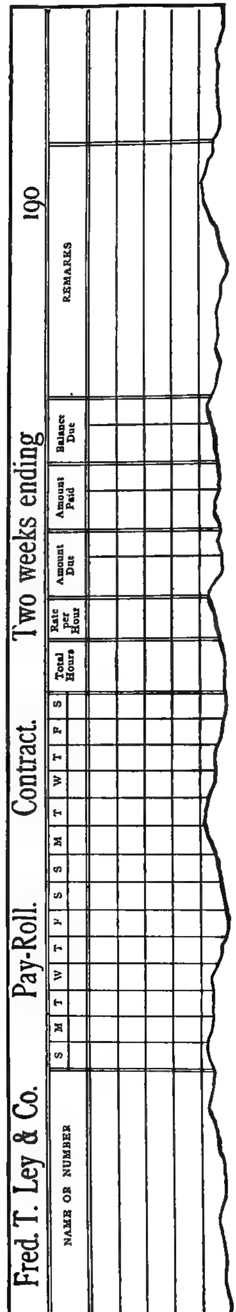


FIG. 178.—Pay-roll.

columns are provided in which to enter cost of dynamite and exploders. The number of feet of hole drilled each day is also recorded, and the number of loads of rock hauled.

Figure 177 is for concrete work, and is self-explanatory. Blank No. 7 (Fig. 178) is the pay-roll blank, and needs no explanation.

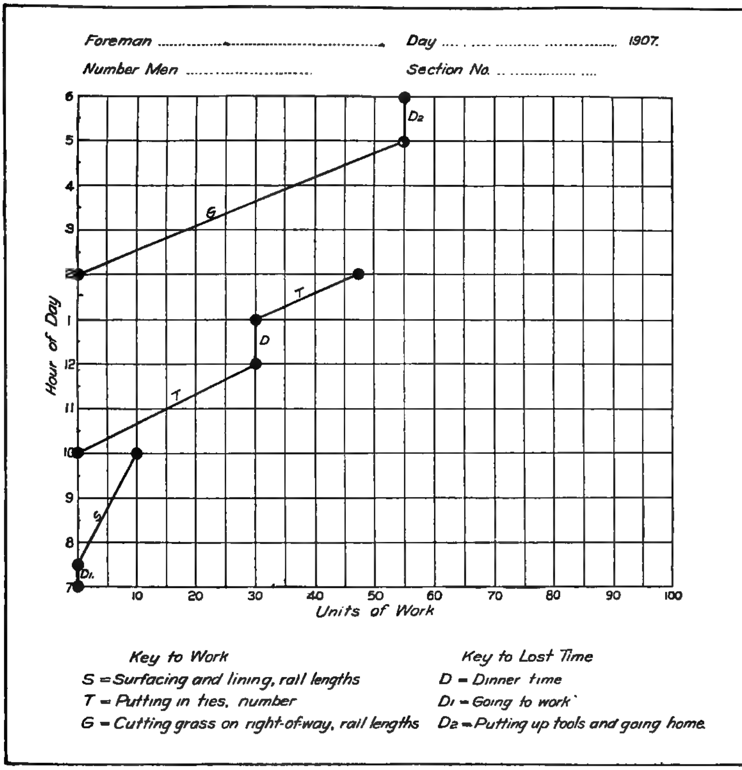


FIG. 179.—Daily punch card record of railway section foreman.

In looking over these blanks we note especially the provision made for recording the work done by each gang of men at each cut, each culvert or bridge, etc., along the line of the work. The blanks are very simple in form, and the system is so flexible that it can be extended to cover many classes of work. The recording of earth and rock excavation by wagon loads or car loads is not absolutely accurate, due to the variation in sizes of loads; but when the number of loads is checked by cross-sections of the

excavation, it will be found that the loads average a certain tolerably constant yardage under given conditions, and, by a little care, the contractor can be quite sure that the foreman is not sending out light loads so as to make a good record for a day's output.

Fred T. Ley & Co. do a great deal of work on the percentage basis, but they keep just as careful a record of cost on percentage work as on regular contract work, not only because they want to keep the unit cost down as low as possible in behalf of their clients, but because a client is able to visit the work at any time, count the men in any gang and check the accuracy of the time keeping for himself.

Record Card for Railway Section Foremen.[1]—The diagram, Fig. 179, is a record card to be used by section foremen, and it shows the day's work done by a gang of section men. The vertical lines, or ordinates, show the hours of the day from 7 A.M. to 6 P.M. and the intermediate quarter hours. The horizontal lines, or abscissas, show the number of units of work accomplished. The black circles are holes punched with a conductor's punch. The lines connecting the punch holes can be ruled in after the day's work is done.

This particular card shows that the gang of men arrived at the site of the day's work and started in at 7:30 A.M. At 10 A.M. they had completed 10 units of work, and the key letter *S* on the straight line between 7:30 and 10 A.M. is found to be the number of rail lengths of track surfaced and lined. At 10 A.M. the gang began putting in ties, as is indicated by the key letter *T* on the straight line between 10 A.M. and 12 M. Then the curve of work rises vertically from 12 M. to 1 P.M., indicating that no work was done during the noon hour. From 1 to 2 P.M. the work of putting in ties was continued. At 2 P.M. the gang began cutting grass, as is indicated by the key letter *G*, and quit at 5 P.M., having cut grass for a distance of 55 rail lengths. Then the curve of work rises vertically from 5 to 6 P.M., and the key letter D_2 shows that this hour was lost in picking up tools and going home.

It will be noted that a card of this sort gives a perfect log of the day's work, showing all delays, their cause and duration, and number of units of work accomplished. On the back of the card a series of key letters should be printed so that the fore-

[1] *Engineering-Contracting*, July 17, 1907.

man can indicate on the curve of work any kind of work done, and the units in which it is measured. The rail length is a convenient unit for certain classes of work; the distance between telegraph poles may serve for other classes. Incidentally, all telegraph poles on each section should be numbered consecutively. Then the foreman can be required to report the exact location of the work by putting the number of the pole on the curve of work diagram.

The card shown herewith is obviously applicable to innumerable kinds of construction or manufacturing where men work as individuals or in gangs. It becomes complicated when a gang under a foreman is split up into smaller gangs which are continually shifted from one kind of work to another. But such shifting is usually unnecessary, and can be obviated, as a rule, by the use of better judgment in the management of the work. Indeed, this very objection to the use of such daily card reports points the way to better management by indicating the lack of reason for splitting gangs up into small units that putter away time.

A Cost-keeping Bookkeeping System for Pipe Line Work.— W. W. Cummings, M. Am. Soc. C. E., has described in *Engineering News* for October 2, 1902, a system of cost-keeping bookkeeping, which description we herewith reproduce:

It often happens that an engineer is confronted by the problem of doing a certain amount of work with a limited sum of money, and the only way he can keep the cost within the required limits is to so systematize the reports that he can see at any time what the expenses are for the different items and trim them accordingly. In the ordinary methods of bookkeeping, unless a considerable force is kept on the accounts, the knowledge of excessive cost is obtained too late to be of much benefit to the work in hand.

In the construction of the Massachusetts Pipe Line Co.'s mains, the writer has occasion to regret that no previously tried system was available, and after considerable study devised the following methods, which may possibly be used as a base in similar cases.

When the Massachusetts Pipe Line Gas Co. commenced to lay its mains, it was given a limit of cost of $9 per lineal foot, complete, which was to include all repairs and changes to other pipes, conduits, sewers and paving. Much of the route was through

districts congested by travel above and obstructed by existing structures below.

The work consisted of laying: 2½ miles of 42-in. pipe, laid in a double line; 3½ of 36-in., double; 1½ of 36 and 30-in., side by side; 7 of 36-in., single; 1 of 24-in. pipe, single. Also three river crossings. Three contractors were employed on the work.

Rates of labor were as follows:

Foreman	$0.45 per hour.
Subforeman	.35 per hour.
Subforeman	.30 per hour.
Bracers	.25 per hour.
Calkers	.25 per hour.
Pavers	4.00 per day (9 hr.).
Tenders	2.00 per day (9 hr.).
Laborers: Derrickmen, bottommen, bracers' tenders, pavers' tenders, pipe layers, leadmen	.20 per hour.
Laborers	.18 per hour.
Laborers	.17½ per hour.
Laborers	.17 per hour
Laborers	.16 per hour
Laborers	.15 per hour.
Blacksmith	.20 per hour.
Blacksmith's helper	.15 per hour.
Lampman	.15 per hour.
Toolman	.20 per hour.
Watchman	.15 per hour.
Carpenter	.25 per hour.

The office force consisted of:

1 bookkeeper	$60.00 per month.
1 timekeeper for each contractor	80.00 per month.
1 timechecker for each gang	12.00 per week.
1 engineer for each contractor	75.00 per month.
1 rodman for each contractor	50.00 per month.
1 yardman for each yard	60.00 per month.

The timekeepers and checkers were men selected for their reliability and diligence and were paid good wages. The checkers patroled the line at irregular intervals, at least every 2 hr., and returned a slip to the timekeeper showing the men and teams at work each trip with the date and time on each slip. The entire route was mapped and separated into divisions and sections. The different cities constituted the divisions, and were let to different contractors, while the sections were divided according to the anticipated character of the work. That which

required piling being one section, that containing rock cut another, where the line crossed private land, passed under the various kinds of street surfacing, was near a railway, etc., each a distinct section. The idea being that the cost of these different classes of work would show in the reports of the sections without further separation.

Five receiving yards were established along the line, where all pipe and material were delivered. Here the pipes were inspected, and a number was marked on the inside of each one with white lead.

MASSACHUSETTS PIPE LINE GAS CO.

DAILY PIPE REPORT.

Contractor .... Received into Park St. Yard. Date July 7th. 1899

CARS Number	CARS Initial	PIPE Size	PIPE Number	WEIGHTS AND ~~TEAMSTERS~~ Numbers			Weights ~~DESTINATION~~	REMARKS
2769	P R R	36"	2576 6	2590/5245 2591/5327	2592/5183 2593/5164	2594/5225 2595/5237	12,624,357 31,381	Mc Neal.
2820	Penna Co	36"	6	2596/5212 2597/5180	2598/5020 2599/5200	2600/5020 2601/5178	30820	Mc Neal.

MASSACHUSETTS PIPE LINE GAS CO.

DAILY PIPE REPORT.

Contractor Mass. P. L. Gas Co. Shipped from Park St Yard. Date July 7th 1899

CARS Number	CARS Initial	PIPE Size	PIPE Number	WEIGHTS AND TEAMSTERS Jackson	Hughe.		DESTINATION	REMARKS
		36"	1 2597	5180			Div 1st Sect. 2. Foreman Colleran	Mc Neal.
		36"	1 2601	5178				

FIG. 180.—Daily pipe report.

A report, Fig. 180, was made in triplicate, containing this data, together with an account of everything shipped from the yard, the division, section and foreman shipped to and the teamster hauling the load. One copy of this report was sent to the office daily, another was forwarded to the auditor and the third remained in the book as a record. The timekeeper was required to return a daily report for each gang, made in duplicate, showing the number of men of different classes employed, the rates of wages, the daily wages and the total wages to date, on each section on one side, while a list of the tools in use with the daily and the total rentals, if any, were sho n on the reverse side. He also noted on this card the numbers of the pipes received and their condition, and the other material received. This report guarded against loss of tools and material in transit to the work.

Of course the total daily pay roll of the card checked that of the time books. Figure 181 describes this report.

The division engineer was required to return daily reports for each section (Fig. 182) made in duplicate, showing the excavation, back-fill, paving, repairs made, material used, the numbers of the pipes laid in their order, with remarks covering anything

FORM 8 1000-11-13-01

MASS. PIPE LINE GAS CO.

Foreman Colman 's Report No. 21

Work .... Date July 7 1899

Location Div. H. Sec. p

	No.	Previous	Hrs.	Rates	Amt.	Total
Foremen	1	90.87	10	.45	4.50	95.37
"	1	35.65	10	.35	3.50	39.15
"	1	36.40	10	.30	3.00	39.40
Laborers	50	3510.90	10	17½	88.50	
"	27		8	17½	37.50	
"	34		10	15	51.00	
"	6		8	15	7.20	3695.40
Firemen					184.50	
Carpenters		71.42				76.42
Blacksmiths		41.60	9	20	1.80	43.40
Caulkers		36.00				36.00
Pavers		9.25				9.25
" Tenders		6.75				6.70

Front.

	No.	Previous	Hrs.	Rate	Amt.	Total
Derricks	1	10.00	10	05	50	12.50
Tool boxes		44.00			2.00	46.00
Furnaces	2					
Blacksmiths' kit	1	15.20			75	15.95
Pumps diaphragm	5					
" rotary						
" steam						
Pulsometers						
"						
Lanterns	117					

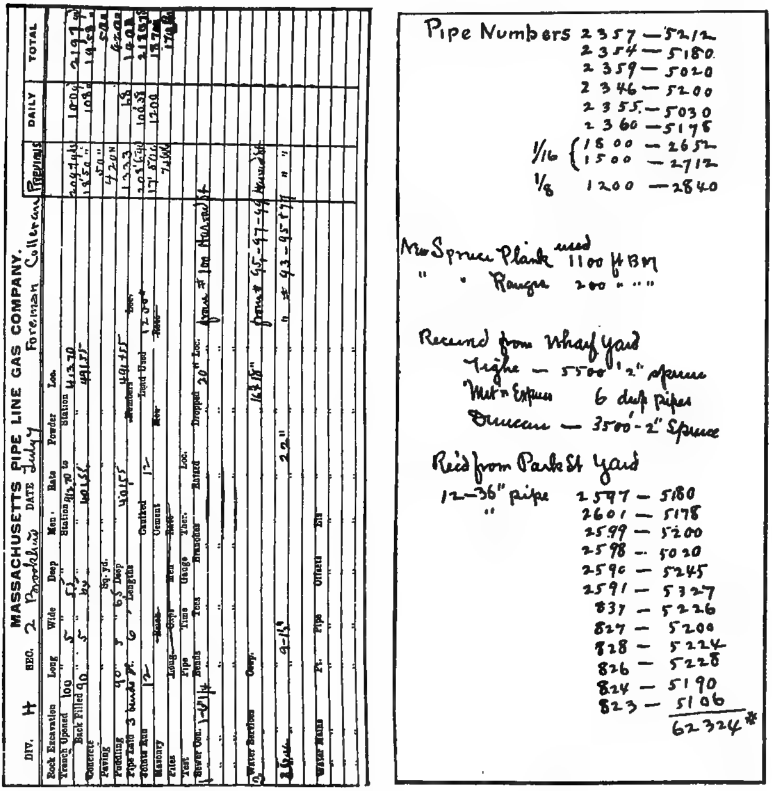
Reverse Side.

FIG. 181.—Daily payroll report, pipe laying.

that would affect the cost. This guarded against the loss of material while on the ground. Both the engineer's and time-keeper's reports were cards of convenient size for the coat pocket, and stiff enough to avoid crumpling, bound in book form,

peforated, and having a thin sheet of parchment for the duplicate.

At the office the bookkeeper entered the pipe as ordered and the data from the cards on a page (Fig. 183), which gives the pipes ordered, received, to come, delivered to each section, laid



Front. Reverse.

FIG. 182.—Daily progress report, pipe laying.

in each section, on hand, and the length as obtained by average laying length (used as a check).

Nearly all the pipe and specials were ordered from the McNeal Pipe & Foundry Co., and the R. D. Wood Co., and the columns headed "McN." and "W." refer to the castings from those dealers.

The bookkeeper also had a ledger account in detail (Fig.

184) which he took from the reports showing the material received, used, and transported from each section. This account

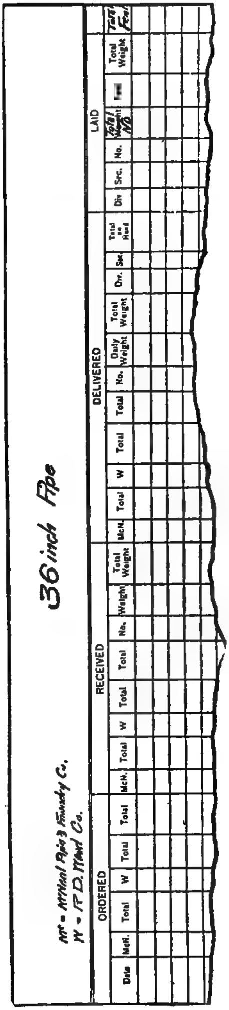


Fig. 183.—Bookkeeper's pipe record.

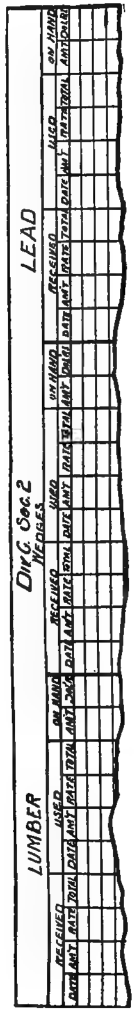


Fig. 184.—Bookkeeper's material record.

served to simplify the entries to be made on the page ruled, as in Fig. 185, and further guard against loss.

In practice the daily report cards from the yards, the timekeepers and the engineers were mailed the evening of the day recorded and reached the office at 8 A.M. The bookkeeper made

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NOTE — * From Wharf Yard.
S " South Boston.

Div. D Sec. 2

DATE	PAVING			In. PIPE					EXCAVATION			LAYING.				BACKFILLING			REPAIRING			HANDLING				SUNDRIES			
190	Sq. Yds.	Rate	Amount	Feet	Weight in Lbs.	Weight in Tons	Rate	Amount	Cu. Yds.	Rate	Amount	Feet	Weight	Rate	Amount	Cu. Yds.	Rate	Amount	Feet	Rate	Amount	Feet	Weight	Rate	Amount	Feet	Rate	Amount	Material
																													30" Pipe
																													36" "
																													30" Drips
																													36" "
																													Wedges
																													Jute
																													Lead
																													Coke
																													Brick
																													Cement
																													Nails
																													Coal
																													Oil
																													Lumber
																													Inspector
																													Car Rail
																													Insurance
																													Tools (rental)
																													Total

FIG. 185.—Bookkeeper's summary sheet.

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Massachusetts Pipe Line Gas Co.—Pipe Record.

	PIPE No.	Wood	McNeal	WEIGHT	DATE TEAMED	Div.	Sec.	TEAMSTER	DATE LAID	FOREMAN	BROKEN PIPE				REMARKS	
											OF FEET	WEIGHT	PRICE	AMOUNT		

FIG. 186.—Bookkeeper's pipe record.

his entries on the pages, described by Figs. 183 and 184, and transferred his totals to the page, described by Fig. 185, which made the information in detail for the day recorded available by noon of the following day.

The results were combined in a similar manner for each division, as shown by Fig. 185, and again for the entire work. These totals were made up each week unless required oftener by the bad showing.

The bookkeeper also compiled a record of the pipe from the yard keepers' and engineers' reports on a page ruled as shown in Fig. 186, by which any lost pipe could be traced and damage assessed.

MASSACHUSETTS PIPE LINE GAS COMPANY.

July 7th, 1899.

FAIR:

Mr. Cummings in office 8:10. Tunnel, Boston, Roxbury, Brookline, Cambridge, office 5:45. Sullivan in office 8:10, 95 Milk St., office till 5. Tabor in office and works all day. Silsbee and Jeeves in office all day. Murry and assistants in Roxbury, Brookline and Jamaica Plain. Hayden and assistant in Cambridge giving grades.

Div. D. Secs. 1 and 2, Cambridge.

Laborers	233	Engineers	2
Carpenters	3	Pumpmen	20
Blacksmiths	1		
Night watchmen	12	Total	270
Day watchmen	10		
Derricks	1	Supply wagon	1
Furnaces	2	Single carts	1
Blacksmith kits	1	Double carts	40
Pumps	5		

302 lanterns out. Sec. 1, ¾-yd. concrete, 140 sq. yds. paving, 60 ft. edgestones, 114 yds. brick laid, 45 ft. pipe laid, 8 joints calked, 8 pigs lead used, 1 sewer connection made—25 ft. 5-in. pipe, 1 6-in. ¼ bend used.

Sec. 2. 175 ft. trench opened, 75 ft. back filled and puddled, 268.84 ft. pipe laid 17 joints calked, 15 pigs lead used, 15 piles driven, 8 caps used.

FIG. 187.—Daily report to president.

A "Division of Labor" sheet, showing the cost of the different items, was sent to the auditor each week. He also received the bills, and kept independent accounts. A daily report, illustrated by Fig. 187, was sent to the president and chief engineer.

The division engineers also kept field books, giving the grade and laying length of each pipe, and the pipe numbers, in the order of their laying. The intersections of cross street lines and important underground structures were noted by station, the locations of each special were tied in to permanent points and the lateral distances from street lines and other pipes, sewers, conduits, etc., were noted.

When repair work was done by city men, a report of the labor, materials and prices was added to the engineer's card, together with the location of the repair. This was credited to the city on a page for that purpose, and when the bill was presented it was "O K'd" from that page.

The highest cost per lineal foot of pipe was $11.61, including all repairs, pipe, etc. This was one 36-in. pipe in rock cut, with a 12-in. gas main on one side and a water pipe and sewer on the other.

The lowest total cost per lineal foot of pipe, for two 36-in. pipes side by side, was $8.16; do., for one 24-in. pipe, $4.29.

The average total cost per lineal foot of pipe was $8.36.

The average total cost of pipe per lineal foot was $4.20, including specials.

The cost of pipe per ton was $17.50 f. o. b. Philadelphia. The cost of specials was 2¼ cts. per pound.

The average cost of excavation (including sheeting) was $1.86 per linear foot; for laying (including lead, etc.), 62 cts.; backfilling (including surfacing), 72 cts.; handling (includes unloading cars and piling in yard) was 76 cts. per linear foot.

This does not include engineering other than as above mentioned. The location sheets were as shown by Fig. 188, giving the station of the side streets and specials, with the lateral distance from street lines and other pipes, conduits, etc., wherever obtainable. Each special is tied in from permanent points, so that any joint can be found by locating a special and measuring the distance given in the field books, while keeping on the offset from the street lines.

A further compilation was started, as outlined in Fig. 189, which is modeled on the form used at Halifax, N. S. This gives at a glance all the information connected with the line, but requires a great deal of time. In the case of the Massachusetts Pipe Line Gas Co., it was reserved for winter work.

In case of repairs and leaks, slips (Fig. 190) modeled after those of the Boston Gas Light Company, W. R. Addicks, engineer, are filled out and filed in a card index under the heading of street names.

Each drip is numbered from the Everett works and a record (Fig. 191) is kept of the depth of drippage and the gallons pumped each visit. The drip wagon contains about 200 gal., and has a float whose spindle is marked every 25 gal. By

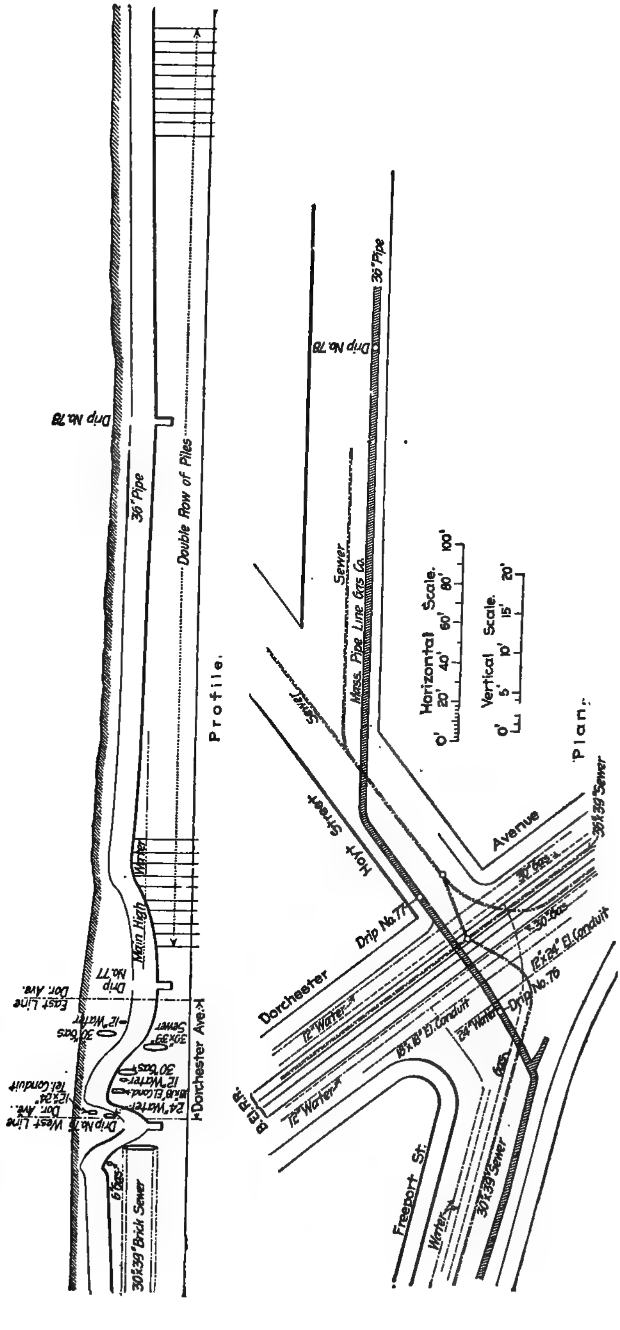


FIG. 188.—Location of pipe line.

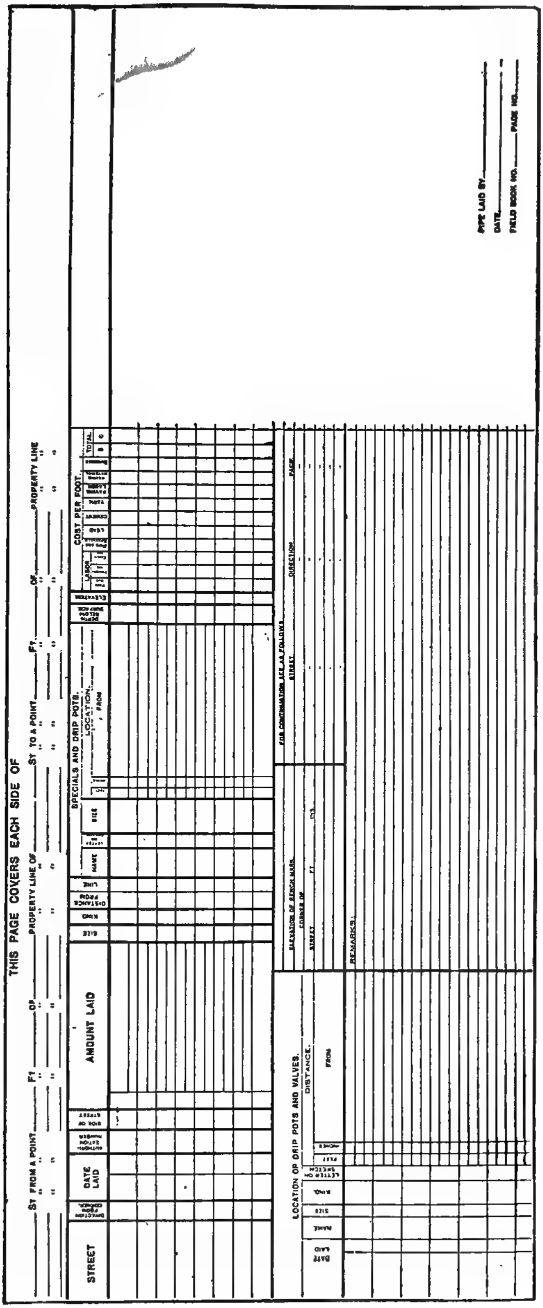


FIG. 189.—Complete record of pipe line.

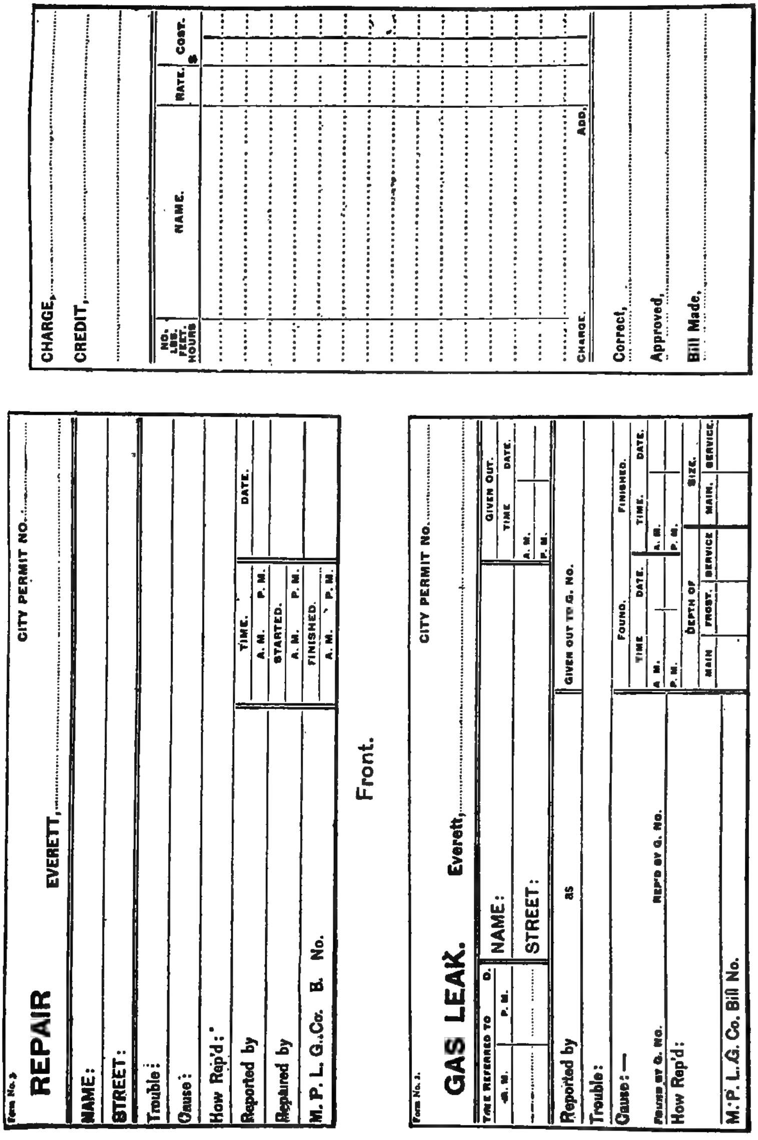


FIG. 190.—Repair and leak blanks.

tabulating for each drip the measurements in inches and the number of gallons pumped, it was easily seen about how much drippage there was for each inch, even though the water extended into the pipe (which is often the case in some drips where the pipes have a slight fall), so that a measurement now gives the approximate gallons to be pumped. Each valve is lettered from the works.

These drips and valves are located in the usual way by stenciling rectangular coordinates on permanent nearby points. All drips are sounded and the valves started once each month.

It would be unfair to close without tribute to the resourcefulness and push of L. J. Hirt, who was the chief engineer during construction.

MASS. PIPE LINE GAS CO.

1899 | 1900

Drip Number	MONTH	DAY	GALS.	Depth	MONTH	DAY	GALS.	Depth	MONTH	DAY	GALS.	Depth	MONTH	DAY	GALS.	Depth
1	Dec 18	Mon		12"	Jan. 19	Fri		38"	Jan. 30	Tues		20"	Feb. 7.	Wed		15"
2	" "	"		10"	" "	"		18"	" "	"		12"	" "	"		0"
3	" "	"		20"	" "	"		22"	" "	"		18"	" "	"		10"
									"	"		10"	" "	"		0"

FIG. 191.—Drip record.

Cost-keeping System of the Kosmos Engineering Co., New York City.[1]—The system about to be described differs materially from any of the systems previously illustrated. It should be stated in advance that the Kosmos Engineering Co. had the contract for building the Brooklyn anchorage for the Manhattan Bridge, the wire cable suspension bridge across the East River at New York City, and that the blanks shown in this article were especially designed for that work. The system, however, is of general application, as will be noted later on.

The first noteworthy feature of the Kosmos system of cost-keeping is the absence of blanks to be filled in by the foremen. The foremen are provided with pads of paper on which they write each day the number of men in the gang and their respective duties and rates of wages. If the work is of a kind that admits of easy measurement, the foreman reports also the amount of work done. On the whole, however, very little is required of the foreman except a statement of the number of men, their occupation and the rates of wages. These he can give on any slip of paper, no printed blanks or rules of procedure being insisted upon.

[1] *Engineering-Contracting*, Mar. 13, 1907.

The foreman's report with the timekeeper's book go each day to the bookkeeper. They, of course, must total up the same amount of daily pay account, and it is the bookkeeper's business to verify this fact. The verified records and time sheet go next directly to the superintendent's assistant, who analyzes them and distributes the costs to the proper accounts. The superintendent's assistant is himself a civil engineer capable of checking all measurements and estimates of quantities. The office is directly on the work so the assistant sees every part of the work himself several times daily. In a word, all analysis of costs is done in the office of a competent man, who is, moreover, in constant touch with the construction work, and so does not require a very elaborate report from the foremen.

Now as to accounts. In this particular contract all costs are charged under six general headings to a number of different items, each of which has its account in the ledger. Of course, the items vary somewhat from time to time, but the accompanying schedule gives a generally fair idea. Keeping to the labor accounts for the present, th superintendent's assistant, in analyzing the foremen's reports and time sheets, record his distribution of cost on blanks 9¾ × 6½ in. in size and of the form show in Fig. 192. These blanks are kept in a filing case and are available for inspection at any time and give a complete record of the labor cost of the work at any time;

The pay-roll vouchers are made out every two weeks and are made out from these blanks. The totals from the blanks are recorded on the back of the voucher in properly ruled spaces. Thus each pay roll voucher is its own record not only of the total pay roll, but of the items making up that total. These vouchers go to the bookkeeper and from them he takes the amounts to be charged to the several accounts. The bookkeeper merely transcribes the amounts.

So far reference has been had entirely to the labor cost accounts. The bills for materials, supplies, etc., are also analyzed by the superintendent's assistant, who proportions or distributes the costs to the proper accounts. This distribution is given on the back of the voucher for every bill, and here again the bookkeeper has simply to transcribe the several amounts to the proper accounts.

The foregoing covers the main scheme for keeping costs. Its noteworthy features are that the foremen are called upon to do

KOSMOS ENGINEERING CO.
BROOKLYN, N. Y.

CONTRACT No. 1

LABOR

GRANITE

DATE	Unloading and Distributing		DRESSING		TRANSPORTING		Hoisting and Setting					
		COST		COST		COST		COST		COST		COST

KOSMOS ENGINEERING CO.
BROOKLYN, N. Y.

CONTRACT No. 1

LABOR

EXCAVATION.

DATE	LABOR IN PIT		STONE BREAKERS		TRANSPORTATION		LOADING and TRIMMING SCOWS		BACK FILLING			
		COST		COST		COST		COST		COST		COST

KOSMOS ENGINEERING CO.
BROOKLYN, N. Y.

CONTRACT No. 1

LABOR

CARPENTERS, ELECTRICIANS.

DATE	CONCRETE FORMS		ARCH CENTERS				ELECTRICIANS		MACHINISTS		WATCHMEN	
		COST		COST		COST		COST		COST		COST

KOSMOS ENGINEERING CO.
BROOKLYN, N. Y.

CONTRACT No. 1

LABOR

FOUNDATION PILES, SHEET PILES AND BRACES.

DATE	SHEET PILING		BRACING		FOUNDATION PILES		PUMPING					
	LINEAL FEET	COST	FT. B. M.	COST	NO.	COST		COST		COST		COST

KOSMOS ENGINEERING CO.
BROOKLYN, N. Y.

CONTRACT No. 1

LABOR

	CONCRETE						CYCLOPEAN			
DATE	MIXING	Transporting	Hoisting and Depositing	TOTAL	CU YDS	Cost Cu Yd	Transportation	Hoisting and Setting	CU. YDS.	Cost Cu. Yd.

KOSMOS ENGINEERING CO.
BROOKLYN, N. Y.

CONTRACT No. 1

LABOR

UNLOADING AND HANDLING CONCRETE MATERIALS.

DATE	CEMENT		CONCRETE STONE		SAND		CYCLOPEAN					
		COST		COST		COST		COST		COST		COST

FIG. 192.—Blanks for distribution of costs.

only the simplest kind of record-keeping and that the analysis of costs and their distribution to the proper accounts are performed

KOSMOS ENGINEERING CO.

DAILY CEMENT REPORT

________________190

NO OF BAGS	Lower Warehouse	Upper Warehouse	Boat	TOTAL
On hand start of day				
Used during day				
On hand close of day				

No. of bags used for Concrete__________

" " " Mortar__________

" " Received__________

Signed__________

FIG. 193.—Daily cement report.

by one of the regular engineering staff who is in constant touch with every detail of the work. It is evident that the system as

KOSMOS ENGINEERING CO.

EMPTY BAG ACCOUNT

Report for________________190

No. empty bags in stock at start of work__________

No. of empty bags placed in stock during day__________

No of empty bags shipped during day

via__________

No of empty bags on hand at close of day__________

Signed__________

FIG. 194.—Daily empty bag report.

described for one specific job is applicable to general contract work by making obvious modifications in details.

DAILY COST OF ELECTRICAL CURRENT CONSUMED.

________________190

Meter No. 1. Anchorage, Present______ Previous______ Diff.______

" " 2. Mixer & Docks " ______ " ______ " ______

" " 3. Railroad " ______ " ______ " ______

" " 4. Arc Lights " ______ " ______ " ______

Total Watts consumed: Anchorage__________ Cost $______

" " " Mixer & Docks__________ " ______

" " " Railroad __________ ______

" " " Arc Lights__________ " ______

Time Previous Readings______ A. M.______ P. M.______

" Present " ______ A. M.______ P. M.______

Remarks__________

__________ Signed __________

FIG. 195.—Daily record of electricity used.

Besides the labor cost blanks shown in Fig. 192, the Kosmos Engineering Co., on the work referred to above, make use of a

variety of other blanks for keeping the daily run of expenses and the condition of the stock of supplies and materials. Figures 193 and 194 show the blanks for keeping track of the cement stock and the empty bag account. Figure 195 shows a blank for keeping tab on the daily cost of electric current consumed. This serves the purpose of checking up the bills rendered for

MOTOR CAR NO.________ Date________190__

Motorman________
Time Started________A. M.________P. M.________
Time Finished________A. M.________P. M.________
No. of Hours at________c. per hour________
Cost for Day________
No. of Cars in Train________
No. of Trips________
Kind of Material hauled________
Amount of Material hauled________

Remarks________

FIG. 196.—Daily record of motor car performance.

current and of detecting waste or other neglect. In a similar way, by means of the blanks shown in Figs. 196 and 197, a daily record is had of the work done by each motor car and hoist. Each hoist, derrick and motor is also inspected at frequent intervals and there are blanks for the inspector's reports. The

HOIST NO.________ Date________190

Operator________
Time Started________A. M.________P. M.________
Time Finished________A. M.________P. M.________
No. of Hours at________c. per hour________
Cost for Day________
No. of Hoists________
Material Handled________

Amount of Oil________
" " Waste________

Remarks________

FIG. 197.—Daily record of derrick performance.

operators of the several machines also have blanks on which they are required to report needed repairs. In a word, the company strives to know by actual reports the condition every day of its machinery, tools, supplies, etc. These detail records are, of course, not absolute essentials of the cost-keeping system proper,

but they combine with that system to make every detail of the work efficient.

Blanks for Recording Work of Well Drills as Used by the Nevada Consolidated Copper Co.[1]—Recording the work done in concise and convenient form is a very important item in prospecting with well drills. Daily time cards should be filled out by each drill man as he comes off the shift. Sample cards are shown by Figs. 198 and 199. The card shown in Fig. 198 is for recording the cost of the work and that shown in Fig. 199 is for keeping a general record of the work. From the daily time cards the superintendent makes up his report to the company at the completion of each hole.

DRILL RECORD

Nevada Consolidated Copper Co.

For the Shift ending..................,190..

Previous depth of hole ....

Present depth of hole ....

Number of feet drilled....................................

Hours drilled....................................

Hours Lost ....

Barrels of water used ....

Cords of wood used ....

Formation....................................

Location of Hole ....

Number of hole....................................

Drill man's wages....................................

Helper's wages $....................................

Cost per foot of drilling this shaf $....................................

REMARKS:....................................

SIGNED....................................

FOREMAN....................................

FIG. 198.—Daily record of test hole drilling.

Form for Keeping Account of Cars of Materials.[2]—George R. Humphrey, member of the firm of Joseph Ross Co., bridge builders and general contractors of Boston, Mass., sends us the form shown in Fig. 200. Mr. Humphrey has used this form for a number of years to keep account of materials received in carload lots.

The form records the number and initial of the car, time of arrival and delivery and also when the car is released. The material man keeps this record and obtains from the railroad

[1] *Engineering-Contracting*, July 3, 1907.

[2] *Engineering-Contracting*, Nov. 20, 1907.

agent the time of arrival. This form is ruled up in a small memorandum book, and on the adjoining page is kept a record of the material received in each car and the amount, such as 15 tons stone, or sand, 12 M. ft. of lumber and other materials.

Mr. Humphrey writes that this record shows at a glance what cars are on demurrage or those about to go on demurrage,

DAILY DRILLING RECORD

Nevada Consolidated Copper Co.

Ruth, Nevada,..............................190..

To..

Mr.....................................General Manager

Drill Rig No. 1

Location. Name of Claim ....

Present depth of hole ....

Previous depth of hole ....

Feet of drilling this shaft ....

Hours drilling ....

Hours lost ....

Drill man's name ....

Helper's name ....

Drill Rig No. 2

Location. Name of Claim ....

Present depth of hole ....

Previous depth of hole ....

Feet of drilling this shaft ....

Hours drilling ....

Hours lost ....

Drill man's name ....

Helper's name ....

Above report is for time ending ....

Remarks ....

FIG. 199.—Daily record of prospect drilling.

thus showing the material man the cars to be unloaded first, when there is more than one car waiting to be unloaded. Bills for materials can also be checked up from this record, and freight bills paid only for cars that have been received.

Being in book form, previous day records can be quickly looked up, and the records of cars received for each contract can be kept in one book and readily filed when the job is completed.

We might add that in addition to the information kept by

CEMENT.					
Note	Car No.	Init.	Arrived	Delivered	Released
	45913	N Y C	9-5 11 am	9-7 2 pm	9-8 9 am
$1 dm	69149	"	" 3 pm	9-8 11 am	9-13 10 am

Fig. 200.—Record of freight cars.

United States Department of Agriculture.
OFFICE OF PUBLIC ROADS.

Daily report of work on Object-Lesson road at .... Date: ....
Weather: .... Length of working day: .... hours. Signature: ....

Force Employed.

	Total in hours or days.	Pay per hour or day.		Total.	
Foremen					
Subforemen on					
Excavation: Men					
Teams					
Shaping: Men					
Teams					
Quarry: Men					
Teams					
Crusher: Men					
Engine and engineer					
Hauling surfacing material.. To crusher					
To road					
Loading surfacing material at					
Spreading surfacing material					
Steam or horse roller					
Sprinkler					
.... masonry					
Shoulder drains					
.... drains					
Water boy					
Watchman					
Total					

Work Done.

Earth excavation	...cu. yds.	Sta. . to Sta. .
Subgrade shaped	...sq. yds.	Sta. . to Sta. .
First course placed	...sq. yds.	Sta. . to Sta. .
Second course placed	...sq. yds.	Sta. . to Sta. .
Surface course placed	...sq. yds.	Sta. . to Sta. .
Road surface completed	...sq. yds.	Sta. . to Sta. .
Material crushed		

Materials Used, Paid for by Unit Measure.

	Quantity.	Price.	Total.	
Surfacing material				
Fuel for crusher				
Fuel for roller				
Oil, waste, repairs				
Drain pipe, sizes				
Cement				
Total				

Remarks: ....

Fig. 201.—Daily report, road construction.
(Engineering-contracting, Nov. 13, 1907.)

Mr. Humphrey, a few columns might be added to show cost of unloading cars and hauling material. One of the authors used a similar form some years ago. Besides showing the record as

S. E. Form 11

STATE OF NEW YORK

Department of State Engineer and Surveyor—Improvement of Public Highways

Construction Report for the ______ *Road*, *No.* ______, *for week ending* ______

______ *County.* ______ *Contractor*

PROGRESS REPORT

Rough grading completed	Sta.	to Sta.	, Lin. ft.	, Total to date, Sta.	to Sta.
Bottom course laid	"	" "	, " "	, " " "	" "
Top course laid	"	" "	, " "	, " " "	" "
Road completed	"	" "	, " "	, " " "	" "
Concrete			Cu. yds.		

No. of days roller worked ______ No. of days crusher run ______

No. of days sprinkler worked ______ No. of days traction engine used ______

LABOR REPORT

	S.	M.	T.	W.	T.	F.	S.	TOTAL	RATE	AMOUNT
Foremen										
Enginemen										
Drillmen										
Masons										
Carpenters										
Laborers										
Teams										
Carts										
Total labor expense for week										

DIVISION OF LABOR EXPENSE

ITEM	AMOUNT
Clearing and grubbing	
Excavation (or embankment)	
Hauling materials for macadam	
Quarrying and crushing stone	
Placing and finishing macadam	
Hauling field stone to crusher	
Concrete	
General expenses	
Total	

MATERIALS REPORT

QUANTITY	ITEM	RATE F.O.B.	AMOUNT	LENGTH OF HAUL TO WORK	REMARKS
Cu. yds.	Bottom course stone delivered at				
Cu. yds.	Top course stone delivered at				
Cu. yds.	Screenings delivered at				
Barrels	Cement delivered at				
Ft. b. m.	Lumber delivered at				
Lin. ft.	Vitrified Pipe (Diam. in.) delivered at				
Pounds	Steel at				
Cu. yds.	Sand for concrete at				
Cu. yds.	" " filler at				
Tons	Coal				
	Total materials expense for week				

EQUIPMENT REPORT

No.	ITEM	MAKE	REMARKS
	Crushers		
	Steam rollers		
	Traction engines		
	Sprinklers		
	Carts or wagons		
	Steam drills		
	Scrapers		

ENGINEERING FORCE ACCOUNT

NAME	S.	M.	T.	W.	T.	F.	S.

In charge

Address

SEE DIRECTIONS ON REVERSE SIDE

FIG. 202.—Engineer's weekly report, road construction.

given here, he had a column for foreman, if one was in charge of unloading, a column for the men, one for the teams, and one to show the approximate length of haul.

This record besides giving a cost of the work done, allowed the contractor to know if the work was done with dispatch and prevented the men from idling away their time, as they are likely to do when a few men are sent off by themselves to do such work. In a column for remarks notation was made if any material or goods were received in bad condition.

Cost-keeping Blanks for New York State Road Work.—In the road work done by the state of New York, each engineer in charge of a road contract is provided with a weekly report blank, shown by Fig. 202, which he is required to fill out from careful

County________ Road No.________ Contractor________

Cost of________from________190 to________190

LABOR ACCOUNT				MATERIALS ACCOUNT				EQUIPMENT	
Time	Rank	Rate	Amt.	Quan.	Item	[illegible]	Amt.	Item	Value
								Total	
		Total				Total			

SUMMARY	
Labor expense	
Materials expense	
Depreciation of plant	
Interest on investment	
Administrative expense, etc.	
Total	
No. of Units	
Cost per Unit	

Description of Work and Conditions

________Observer

FIG. 203.—Special cost report, roadwork.

notes taken throughout the week. These reports are the basis for the progress charts showing the rate of progress on each contract. They also furnish the necessary information for the cost data department. Special cost blanks like the one shown by Fig. 203 are also furnished. These reports are used in cases where exceptional opportunity offers to obtain the cost of any item of work.

The inspectors on the work keep an accurate account of the number of men employed and materials furnished, and report them daily to the engineer in charge. On the last of each month estimates are made out and sent to the division engineer, by the engineer in charge of the work, for the amount of work done during the month. These estimates are checked and signed by the

division engineer and forwarded to the state engineer. They are again checked and compared with the original contract on file in the state engineer's office, and if found to be correct, the contractor is paid 90 per cent of the said estimate.

Discussion of Cost Keeping: Smelting Plant, Railroad, and U. S. Reclamation Service—Construction.—We reprint herewith some discussions of a paper on cost keeping by Myron S. Falk and published in *Transactions* Soc. Am. C. E., Vol. LXIV, p. 401. We would call particular attention to the last paragraph of Mr. Hammatt's discussion. Note also his distinction between fixed and movable plant. In his work a good deal of plant may be classed as fixed; while in ordinary contract work most of the plant is movable.

W. C. Hammatt, Assoc. M. Am. Soc. C. E. (by letter).—When in charge of various pieces of construction, the writer has always endeavored to keep close and accurate costs, in order to check, not only the unit costs of different classes by previous work of the same class, but also to present to the company, at the end of the work, an accurate and minutely itemized valuation of the work done, for inventory and insurance purposes. He has used practically the same system in his work as Superintendent of Construction for the Mountain Copper Company, at Martinez, the American Smelting and Refining Company, at Chihuahua, Mexico, and the Mammoth Copper Mining Company, at Kennett Cal.; therefore, only one of these cases, for example, the construction at Chihuahua, will be described.

The first step of the system involved giving a segregation number to each piece of work. This minimized the clerical work, and also gave convenient reference to ledger accounts. In this system of segregation whole numbers are used for the main divisions of work and decimals of various length for the sub-segregations under these divisions. This provided for a combination of all the decimals of a certain degree when segregations of lesser refinement were necessary for certain purposes. For example:

Construction Schedule

General Expense:

01 Superintendence.
02 Surveying and drafting.
03 Office expenses.
04 Proportion, main office.
05 Temporary tracks.
06 Tools, push cars, concrete mixer.

07 Real estate.
08 Warehouse stock.
09 Warehouse expense.

Blast Furnaces:

10 Building.
11 Furnace No. 4, bustle pipe settler, etc.
12 Changes in present furnaces.
13 Slag and matte equipment.
14 Furnace No. 5, bustle pipe, settler etc.
15 ....
16....................
17 ....
18 Connecting blast pipe.
19 Blast pipe in smelter.

(These sub-heading apply to all following headings.)

0.1 Grading.
0.2 Forms.
0.3 Concrete.
0.4 Superstructure.
0.5 Falsework.
0.6 Plumbing.
0.7 Wiring.
0.8 Painting.

Converter Plant:

20 Building (including crane).
21 Converter No. 1 (including stand and tilting system).
22 Converter No. 2 (including stand and tilting system).
23 Downtakes.
24 Flue.
25 Charge system.
26 Copper disposal.
27 Slag disposal.
28 Blast pipe.
29 Hydraulic system.

Relining System:

30 Building.
31 Relining pit (including tamper and crane).
32 Clay mills.
33 Clay and quartz bins.
34 Track and trestle to same.
35 Tunnel.
36 Drying stands.
37 ....
38 ....
39 ....

Charging System:

40 Tunnel.
41 Trestle.
42 Trackwork.
43 Equipment, charge cars.
44 ....
45 ....
46 ....
47 ....
48 ....
49 ....

Flue System:

50 Dust chamber, steel work (including hoppers)
51 . . . .
52 . . . .
53 . . . .
54 Tracks.
55 New stack.
56 Equipment, cars, etc.
57 . . . .
58 . . . .
59 . . . .

Power Plant and Blast Mains:

60 North addition (building).
61 South addition (building).
62 Receiver.
63 Changes in present blowers and connections.
64 Blower No. 4 and connections and motor.
65 Blower No. 5 and connections and motor.
66 Blowing engine.
67 Blower No. 6, connection and motor.
68 Blower No. 7, connection and motor.
69 Generating set No. 2.
70 Switch-board.
71 . . . .
72 . . . .
73 . . . .
74 . . . .
75 . . . .

Sampling System:

76 Temporary sampling room.
77 . . . .
78 . . . .
79 . . . .

Track System:

80 Standard gauge changes.
81 New standard gauge yard.
82 Slag tracks.
83 Lime track.
84 Track scales.
85 . . . .
86 . . . .
87 . . . .
88 . . . .
89 . . . .

0.1 Grading.
0.2 Track-laying.
0.3 Ballasting.
0.4 Switching.

Shops:

90 Machine-shop building and blacksmith shop.
91 Machine-shop plant.
92 Steel shop building.

93 Compressor-motor and building.
94 Boiler-shop and round-house building.
95 Boiler-shop and round-house plant.
96 Carpenter shop building.
97 Carpenter shop plant.
98 Electrical shop building.
99 ....

Bins and Trestles:

100 Main receiving bins.
101 Trestle approach to same.
102 ....
103 ....
104 ....
105 ....
106 ....
107 ....
108 ....
109 ....

Miscellaneous:

110 High-pressure pipe line.
111 Cement sheds.
112 Greek bunk house.
113 Drain tunnel.
114 Smelter stable.
115 ....
116 ....
117 ....
118 ....
119 ....

Standard Gauge Equipment:

120 Oil tank.
121 Locomotives.
122 Wrecking crane.
123 Cars.
124 ....
125 ....
126 ....

In regard to this list, it may be stated that it is faulty in its arrangement, due to the full plans for construction not being complete at the time the work was started. The writer believes in a more complete segregation of fixed and movable plant, for insurance and appraisal purposes, as a machine can be moved to a new site, while its foundation can not, and the superstructure of a building is subject to destruction and damage by fire, while its foundation is not.

In the matter of construction reports: The forms of two re-

ports used for cost keeping from day to day are given in Figs. 204 and 205. That shown by Fig. 204 was made out daily by the foreman for each kind of work done under his supervision, a separate report being made out for each segregation. At the end of the week the form shown by Fig. 205 was made out by the cost clerk from the data on Fig. 204, and the measurement or estimate of each piece of work performed. The form shown

AMERICAN SMELTING & REFINING CO.
CHIHUAHUA PLANT

Daily report of labor on____________
for____________
Segregation____________
Date____________

NO.	EMPLOYEES	NO. HRS.	RATE	AMOUNT
	Foreman			
	Carpenters			
	"			
	Helpers			
	Mechanics			
	"			
	"			
	Helpers			
	Stone Masons			
	Brick "			
	Helpers			
	Engineers			
	Firemen			
	Plumbers			
	Helpers			
	Electricians			
	Laborers			
	"			
	Water boys			

____
FOREMAN

Standard size, 7 by 3⅝ in.

FIG. 204.—Foreman's daily report.

AMERICAN SMELTING & REFINING CO.
CHIHUAHUA PLANT

Cost report for____________
______on____________
Segregation____________
Ending____________

DATE	ACCOUNT	UNITS	RATE	AMOUNT
	Labor			
	do			
	do			
	do			
	do			
	do			
	do			
	Brick			
	Stone			
	Sand			
	Lime			
	Cement			
	Lumber			
	Cost per unit			

____

Standard size, 7 by 3⅝ in

FIG. 205.—Cost clerk's weekly report.

by Fig. 204 was also used by the timekeeper as a check on his time, as the total number of man-hours or man-days should agree in both cases, and also the total in dollars and cents for the pay period.

As there is likely to be inaccuracy in progress measurements which are taken daily, or even weekly, it is well to combine the reports of several weeks. These inaccuracies will then disappear, and a truer calculation of unit cost may be made.

This system had to be varied for the different conditions under which the construction work was conducted, for example, in Mexico, where the foremen were mostly illiterate; special men were employed for the cost keeping, and the forms differed slightly from those used in places and on classes of work where men of better mental capacity were employed.

Bills for materials of construction were distributed by the superintendent or cost clerk at the time of checking to the accounts where they belonged. When bills could not be charged to their regular jobs, on account of the actual quantity of material going to each job being unknown, the total was charged to warehouse, and the different jobs debited and warehouse credited as the material was issued.

It may be added that the engineer generally works under difficulties in keeping accurate cost records, as the general idea among American employers is that such data are useless expense, and they will not allow the necessary clerical force to make them accurate and useful. The sentiment among most of them was expressed in the late T. S. Austin's remark to the writer that whether the brickwork costs $12 or $30 per 1,000, the work would go on until it was completed or the company "went broke."

Emile Low, M. Am. Soc. C. E. (by letter).—On construction work it is always interesting for the engineer-in-charge to know, at least approximately, what the work is costing the contractor. For want of absolute knowledge of the cost of some items, it may be difficult to ascertain the total cost, but even a knowledge of the cost of some of the items, as before stated, is of some satisfaction.

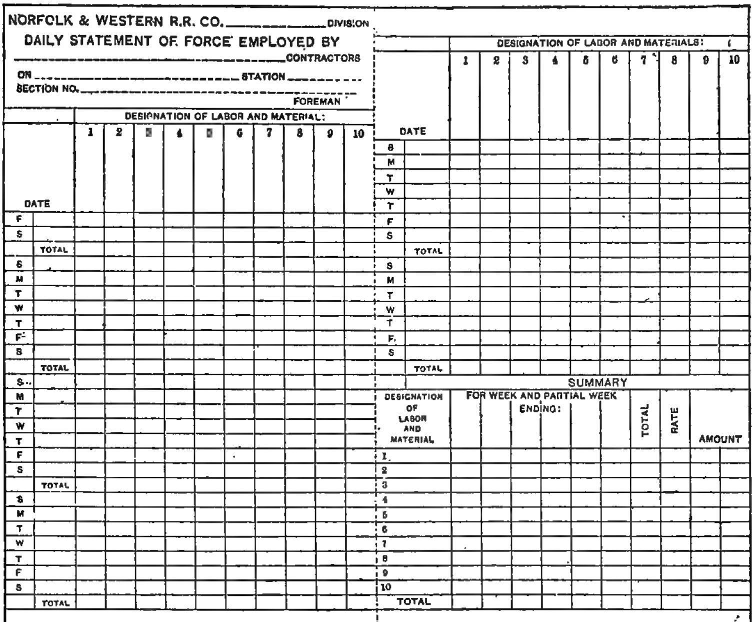
It may be stated with some assurance that, during construction, nearly every railroad company keeps some kind of a force account, which is rendered to the chief engineer, generally weekly, by his subordinates.

Some years ago, while the writer was in charge of some heavy railroad construction in Southwestern Virginia, he originated and put into effect a system of cost keeping, which showed monthly the cost to the contractor of various classes of work, the statements of which were submitted with the monthly estimates.

The system was extremely simple, and consisted essentially of three blank forms which constituted the basis for keeping the records.

On the railroad in question, each residency consisted of from seven to ten 1-mile sections, thus each residency ranged from 7 to 10 miles in length. The contractor's forces were counted daily by a timekeeper employed by the railroad company, which work comprised his whole duty.

A special timebook was prepared, a double page of which is shown by Fig. 206.



NORFOLK & WESTERN R.R. CO. ________ DIVISION
DAILY STATEMENT OF FORCE EMPLOYED BY
________ CONTRACTORS
ON ________ STATION ________
SECTION NO. ________
FOREMAN ________

DATE		DESIGNATION OF LABOR AND MATERIAL: 1	2	3	4	5	6	7	8	9	10
F											
S											
	TOTAL										
S											
M											
T											
W											
T											
F											
S											
	TOTAL										
S											
M											
T											
W											
T											
F											
S											
	TOTAL										
S											
M											
T											
W											
T											
F											
S											
	TOTAL										

DATE		DESIGNATION OF LABOR AND MATERIALS: 1	2	3	4	5	6	7	8	9	10
S											
M											
T											
W											
T											
F											
S											
	TOTAL										
S											
M											
T											
W											
T											
F											
S											
	TOTAL										

SUMMARY

DESIGNATION OF LABOR AND MATERIAL	FOR WEEK AND PARTIAL WEEK ENDING:						TOTAL	RATE	AMOUNT
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
TOTAL									

Standard size, 7 by 8½ in.

FIG. 206.—Record of labor and materials, railroad construction.

From an inspection of the timebook it will be noted that it is arranged to keep a separate record of each and every piece of work, no matter what it may be. It is also arranged to show the totals for each full week as well as for the partial week. Occasionally, there is a month which includes 4 full weeks and parts of 2 weeks, making space for six entries necessary.

The usual practice is to send in the force accounts weekly to headquarters, and the arrangement of the book facilitates this. At the end of the month there is a summary from which the cost of the work is obtained.

Of course, owing to the method used, the cost obtained is not absolute, as the force employed during the morning and afternoon may vary in numbers, the timekeeper passing over the work

---------------------------RAILROAD CO.,

COMPARATIVE STATEMENT

ESTIMATE vs. EXPENSES

RESIDENCY NO.---------- ESTIMATE NO.------

SECTIONS NOS.---------- --------------DIVISION

MONTH OF--------------- -----------CONTRACTOR

	CLASS OF LABOR	RATE	SEC.			SEC.			SEC.			SEC.		
			NO.	AMOUNT		NO.	AMOUNT		NO.	AMOUNT		NO.	AMOUNT	
CLEARING	Foremen													
	Laborers													
	Teams													
	Total Labor													
	Estimate													
	Difference													
GRUBBING	Foremen													
	Laborers													
	Teams													
	Total Labor													
	Estimate													
	Difference													
GRADING	Foremen													
	Laborers													
	Teams													
	Blacksmiths													
	Carpenters													
	Total Labor													
	Superintendence													
	Explosives													
	Total Expense													
	Estimate													
	Difference													
MASONRY	Foremen													
	Stone Cutters													
	Masons													
	Laborers													
	Teams													
	Total Labor													
	Estimate													
	Difference													

Standard size, 8½ by 10½ in.

FIG. 207.—Monthly summary, railroad construction.

only once a day. Where absolute accuracy is required, more timekeepers would have to be employed.

As there are no printed headings, the spaces may be filled in as the nature of the work requires. Space is provided for ten

different designations of labor and material, and in cases where there are more items, other pages can be used. It will be seen that the timebook is very flexible, and can be adapted to any contingency.

At the end of the month all work is classified, the form, Fig. 207, being used. The sample sheet shows columns for clearing, grubbing, grading, and masonry. This column is left blank, and the various classes of work are written in, using as many sheets as necessary.

Before the final classification, by sections, the location ofeach individual piece of work is entered in the column having the printed heading, "Sec." On the grading there may be as many as ten or more forces at work on a mile section; several culverts, bridge abutments, and piers may also be building.

The blank form, Fig. 207, may be used in making a compilation showing the cost for separate localities, or the totals for any one section may be entered, these totals being obtained by the addition of the various separate items.

Figure 208 is a blank form showing the summary of all the work on a contract.

The main idea underlying the whole scheme is to make a monthly comparison with the engineer's estimate.

Referring to the timebook, Fig. 206, there is on a page the cost to the contractor of a particular piece of work, during the month, say a bridge abutment. An estimate of quantities and cost has been made by the engineer in charge of this particular work.

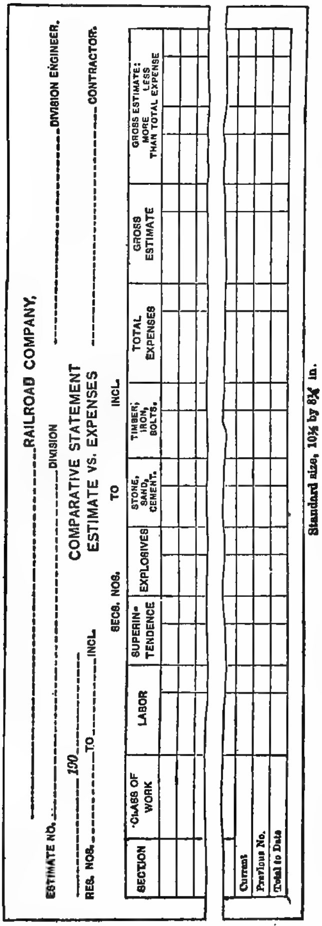
The details of the cost to the contractor are transferred to the blank form, Fig. 207, the amounts being shown under the heading marked "Sec.," the "estimate" placed under the total, and the difference obtained, which will be more or less as the case may be. These statements then show in detail the expense and estimate of each particular piece of work.

Then a summary is made of each and every kind of work by sections (1 mile), and also a summary of the various estimates. These summaries then show, mile by mile, the status of the various kinds of work.

The engineer's estimate always shows the total cost of a section, and in order to make a proper comparison of all expense, another blank form is needed, which shows a summary of all the labor, superintendence, explosives, stone, sand, cement, timber,

iron, bolts, etc., this being the total cost of all the work in a section.

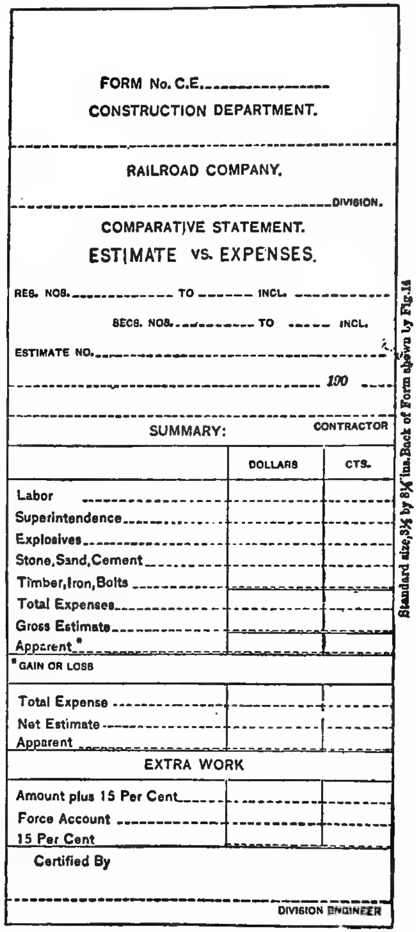
These totals, shown by Fig. 209, may be readily obtained by using the form shown by Fig. 208, for the purpose of tabula-


RAILROAD COMPANY.
DIVISION
DIVISION ENGINEER.
ESTIMATE NO.
190
CONTRACTOR.
COMPARATIVE STATEMENT
ESTIMATE VS. EXPENSES
RES. NOS. TO INCL.
SECS. NOS. TO INCL.

SECTION	CLASS OF WORK	LABOR	SUPERINTENDENCE	EXPLOSIVES	STONE, SAND, CEMENT	TIMBER, IRON, BOLTS	TOTAL EXPENSES	GROSS ESTIMATE	GROSS ESTIMATE: MORE LESS THAN TOTAL EXPENSE
Current									
Previous No.									
Total to Date									

Standard size, 10½ by 8¼ in.

Fig. 208.—Monthly summary of actual and estimated costs, by sections.


FORM No. C.E.
CONSTRUCTION DEPARTMENT.
RAILROAD COMPANY.
DIVISION.
COMPARATIVE STATEMENT.
ESTIMATE VS. EXPENSES.
RES. NOS. TO INCL.
SECS. NOS. TO INCL.
ESTIMATE NO.
190
SUMMARY: CONTRACTOR

	DOLLARS	CTS.
Labor		
Superintendence		
Explosives		
Stone, Sand, Cement		
Timber, Iron, Bolts		
Total Expenses		
Gross Estimate		
Apparent*		

*GAIN OR LOSS

Total Expense		
Net Estimate		
Apparent		

EXTRA WORK

Amount plus 15 Per Cent		
Force Account		
15 Per Cent		

Certified By

DIVISION ENGINEER

Standard size, 3¾ by 8¼ ins. Back of Form shown by Fig. 14

Fig. 209.—Monthly summary of actual cost and estimated costs, entire contract.

tion, as the main items are all placed in separate columns, and can be easily added. In some quarters objection is made to keeping an accurate account of the forces employed by the contractor and the tabulated cost, the main reason assigned being that the

engineer's estimate is influenced thereby to some extent. This need not be, as the cost to the contractor is not generally known until some time after the estimate is made out. In most public works nowadays there is no classification of excavation, so there are no grounds whatever for manipulation, although there might be under the classification method of dividing excavation into earth, hardpan, and loose and solid rock.

Again, the contractor's cost may be tabulated wholly in the division engineer's office, or even in the office of the chief engineer, he being furnished with duplicate copies of the timebooks, which, as before stated, form the basis of the whole system described.

The writer is a firm believer in keeping costs of contractor's operations, for the very important reason (and almost the only one) that it affords some tangible evidence of fixing suitable unit prices on future work, instead of using that very undesirable makeshift, guessing at them.

F. H. Newell, M. Am. Soc. C. E. (by letter).—The following comments, prepared by V. C. Croissant, are offered with the hope that they may be of value.

A careful reading of Mr. Falk's paper leads to the conclusion that the system described is for use on work which is highly centralized. The contracts are evidently for compact pieces of work in a city. The opening paragraphs state very clearly the real value of cost-keeping data in the great majority of construction operations, and are especially pertinent to those for which this system is applicable. The method described would result in accurate data covering prime costs of any class of work in which labor was the principal cost element.

It should be noted that there are two sources of error in cost accounting which seem to be almost impossible of complete elimination. With the presence of possible errors due to either or both of these causes, the results are practically valueless to any contractor except (as stated by Mr. Falk) the person actually preparing the data. Even he may be so deceived by his own calculations as to find the bankruptcy courts eventually his only relief. These sources of error are:

1. The substitution of estimates for certainties, in the case of the engineer or proprietor who is so thoroughly impressed with the value of direct and prompt information that he uses assumptions (in many cases purely guesses) for actual mathematical facts

Such a man gathers daily all the data possible, and, because of a lack of system or of a comprehensive plan, fails to consider many items, such as unpaid purchases, unpaid labor, depreciation on plant, interest on investment, the value of his own time, and supplies consumed which are not measureable in the completed units of work, but which, nevertheless, are fundamental and positive cost elements. His main ambition is to "know from day to day how things are going." To do this, he arrives at theoretical results by a series of allowances, the component elements of which are not certainly known. He may guess at them, or he may omit them entirely. His hypothesis may be satisfactory where the work to be done is small, and highly centralized, and when the engineer making the estimates is of large experience and excellent judgment.

2. The delay for accuracy which occurs with the book keeper or cost-keeper who is professionally proud of his work, and so short-sighted as to make absolute accuracy his main concern. Such a man insists on the results being unassailable from any and every angle; the figures must "balance," or "square into" everything that bears on the accounting of the firm. This makes for accuracy—eventually—but the results are largely historical, and, after being neatly typewritten and "tied into" all related statements, are allowed to see the light of day long after the evils which they might have corrected are forgotten by the "man on the job." They are simply the autopsy of a dead transaction, not a diagnosis of the progress of a vital case.

The plan presented by Mr. Falk is one which requires a single book, namely, the cashbook. It would appear that all liabilities must be paid immediately; and that everything purchased in the way of supplies must go into the work immediately. If such is not the case, then future liabilities will not reach the cost acounts untilt he supplies represented are paid for. If supplies are purchased against a future need, they will be charged in the month paid rather than in the month used.

A cashbook, of course, cannot be used to record estimated depreciation on equipment used from month to month. If the work is done largely by expensive equipment, this important element of cost, depreciation, is overlooked. Interest upon ivestment would be entered from time to time if money was borrowed and interest paid at the bank. If the capital is actually paid in by the proprietors, and, consequently, no regular interest pay-

ment is made, then the cashbook would not record the legitimate earning on this capital to which it would be entitled. The old accounting question of whether bookkeeping should deal with cash receipts and disbursements, or whether it should deal with the question of values received and expended, whether paid for or not, is the one which really comes to the front. It was settled long ago in favor of the latter method.

For a small business, the cashbook may be the only record necessary, but for operations which are extensive, it is, perhaps, the smallest part of the necessary bookkeeping records. The same rule may be laid down to decide whether or not cost keeping shall become a part of bookkeeping. In small operations, it is quite possible to arrive at very accurate costs by a system of card records entirely independent of bookkeeping, but, for large works, the elements of cost are so numerous that a well-defined automatic system, governed or controlled by analytical accounting method, must be adopted in order ot insure complete records.

In the United States Reclamation Service a system has been adopted in which an attempt has been made to harmonize the views and serve the purpose of both the engineer and the accountant. In all Government work it is necessary, in addition to having the available results for the immediate use of engineers, foremen, etc., to make a permanent record of costs, since that work is subject to investigation by commisions, and by the public; and the expense of construction must be brought within a specific appropriation or allotment of funds, which corresponds to a commercial contractor's bid price for a given undertaking.

The system adopted by the Reclamation Service has been devised in order to place in the hands of the man locally concerned a complete record, which is available for his inspection from day to day, and shows the prime cost of all work. This prime cost takes up the charges for all labor, material, and supplies used; these records are entered daily, and, by the use of the adding machine, totals under any classification of expense, or for all classifications under any feature, can be known in a few hours. After the local cost-keepers have finished this tabulation the results go to the bookkeepers, who add the top extrinsic costs, such as administration, depreciation, and all the other expenses, which are unknown to the timekeepers and storehouse clerks. These are finally assembled in the project offices, and monthly statements for each feature are transmitted to the general office in Washing-

ton. When any large, or important feature is finally completed, the project engineer prepares from these local records a cost report showing the cost by units of work done, which is analyzed into all the elements of labor, material, supplies, power, depreciation, superintendence, general expense, etc.

By the method used in the Reclamation Service, the principal machinery for assembling costs is:

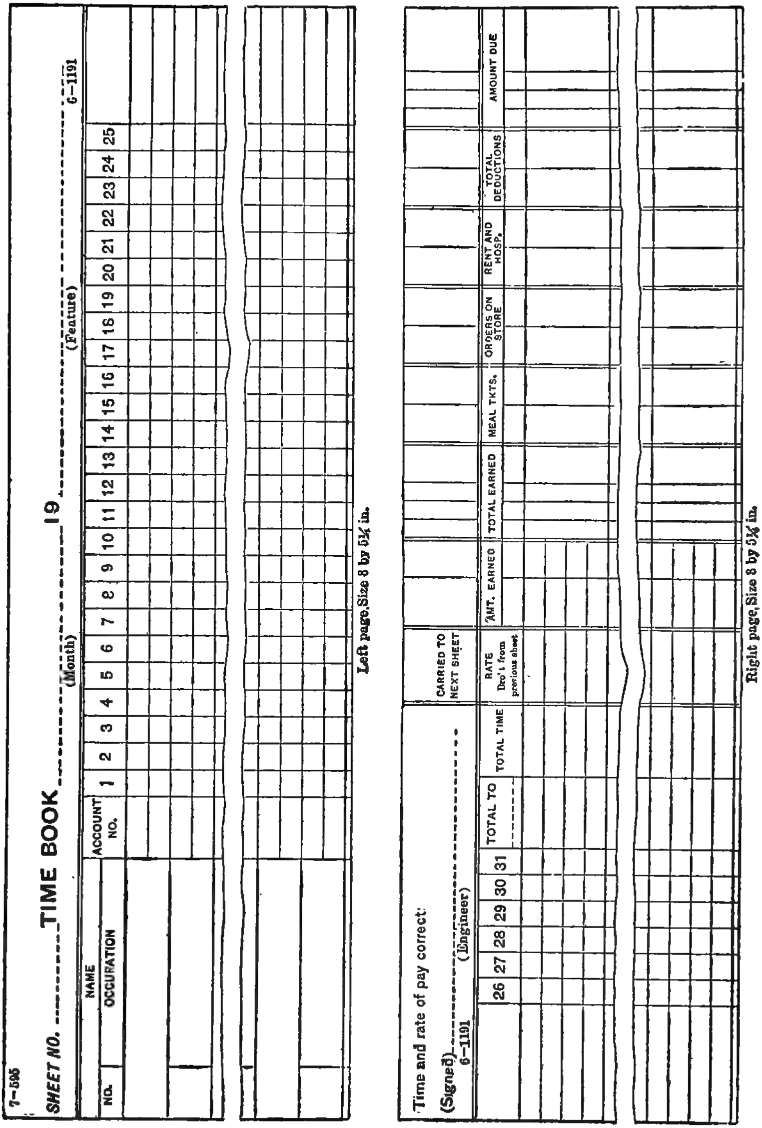
1. *An Account Number Book.*—Each feature or job of work is assigned a set of numbers, as many being reserved as will be necessary to give each classification of expense a number. The following is an example:

Dam for reservoir.

260 Superintendence and engineering.
261 Labor, foremen.
262 Labor, masons.
263 Labor, cranemen.
264 Labor, teamsters.
265 Labor, timekeepers and clerical.
266 Labor, laborers.
267 Labor, animals owned and hired.
268 Labor, blacksmiths.
269 Labor, drillermen and machinists.
270 Supplies, cement.
271 Supplies, powder, dynamite, fuse, etc.
272 Supplies, drill steel.
273 Supplies, lumber.
274 Supplies, power.
275 Supplies, miscellaneous supplies.
276 Supplies, labor and repairs.
277 Employers' liability.
278 Depreciation on equipment.
279 General expenses.

2. *Timebooks.*—These books are ruled so that the time of each employee may be shown for each class of work performed. When the timekeeper takes time, he makes the proper notation, indicating the hours worked and the class of work. Figure 210 is an illustration of a timebook adapted for this purpose.

3. *Requisitions.*—All supplies, materials, etc., ars ued issfrom storehouses at cost plus freight and a percentage addition to cover handling and storehouses expense. For this purpose a requisition blank, Fig. 211 is used. Each foreman is supplied with a list of account numbers which are allotted to the features of work in his immediate charge. When he makes up a requisi-



7-595

SHEET NO. ______ TIME BOOK ______ 19 ______
(Month) (Feature)
6-1191

NO.	NAME / OCCUPATION	ACCOUNT NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

Left page, Size 8 by 5¼ in.

Time and rate of pay correct:
(Signed) ______
(Engineer)
6-1191

CARRIED TO NEXT SHEET

26	27	28	29	30	31	TOTAL TO ______	TOTAL TIME	RATE Dro't from previous sheet	AMT. EARNED	TOTAL EARNED	MEAL TKTS.	ORDERS ON STORE	RENT AND HOSP.	TOTAL DEDUCTIONS	AMOUNT DUE

Right page, Size 8 by 5¼ in.

Fig. 210.—Timebook, U. S. Reclamation Service.

tion, he indicates, opposite each article ordered the classification to be charged, by inserting the account number assigned to that

DEPARTMENT OF THE INTERIOR
U. S. RECLAMATION SERVICE

REQUISITION
No. ....

.... *PROJECT*

.... *19*

To STOREHOUSE CLERK:
Please furnish the following on account of the ....
.... feature:

ACCOUNT NO.	QUANTITY		ARTICLES	UNIT PRICE	TOTAL
	WANTED	FURNISHED			
	Original (on white paper) goes to cost keeper				
		for entry in classification book			
	Duplicate (on pink) remains with storehouse				
		clerk for his protection			
	Triplicate (on yellow) is returned to foreman				
	as an advice of cost of goods furnished				

Deliver to ....

For forwarding by ....

Wagon Bill of Lading No. ....

(Signed) ....

....

Received the articles above listed *as furnished*

(Signed) ....

....

Standard size 5⅜ by 7⅞ in.

FIG. 211.—Requisition blank, U. S. Reclamation Service.

classification. The storekeeper enters on the requisition the unit price and total value of supplies issued.

4. *General Classification Book.*—The book, Fig. 212, is used to assemble the items of expense under each classification. Each folio is ruled with ten columns, and the columns are numbered from 0 to 9. The first folio is not numbered, and the columns 0 to 9 will represent the classification indicated; the second folio is numbered 1. Reading the column numbers as the units with the folio number as the tens, the columns on folio No. 1 will assemble the charges against classifications Nos. 10 to 19. Any number of account numbers can be added by inserting additional folios, as this is a loose-leaf book. There are 31 horizontal lines—one for each day of the month—and a few additional for special entries at the end of the month, as depreciation, interest, etc.

The amount of charges appearing on requisition is entered daily in the respective columns, and the earnings of employees, as shown by timebooks, may be thus noted. The foreman or engineer wishing to know the cost of work of any particular feature at any time has only to ask the cost keeper to add up the colmuns representing the classifications assigned to that feature, and he will have the total cost for labor and supplies expended to that date.

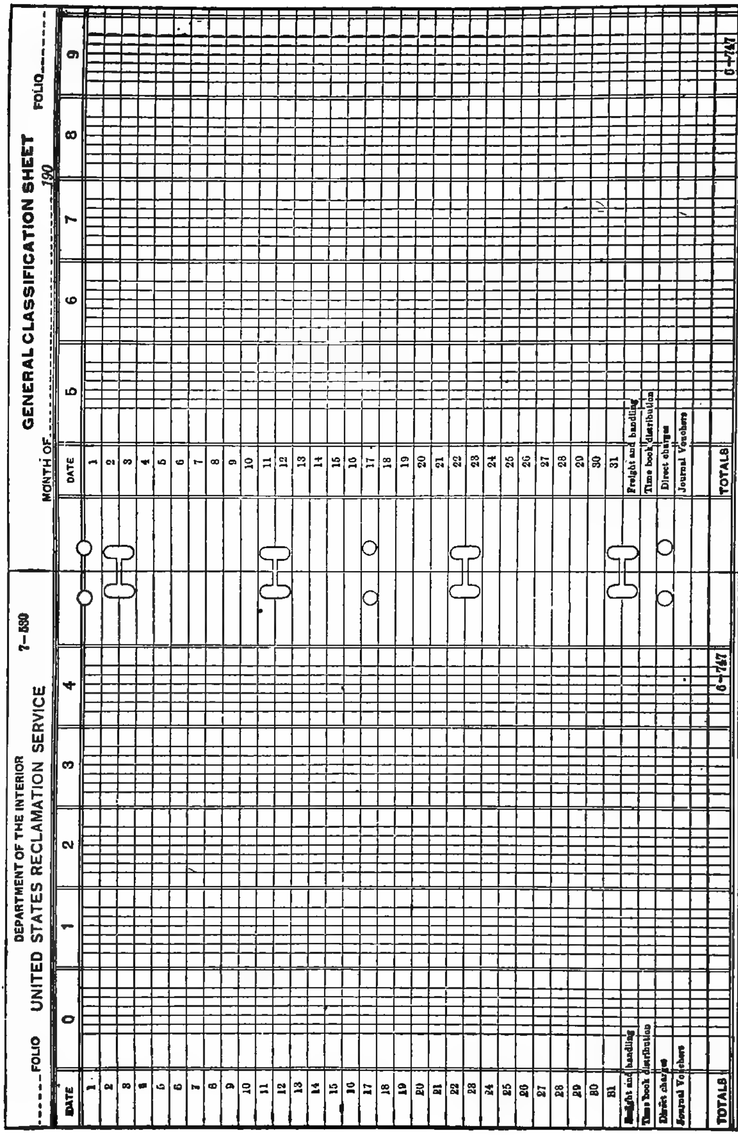
At the end of the month these sheets are removed from the binder and sent to the bookkeepers, who add the top costs and post the total for the month to the cost ledger which contains all charges for previous months, thus making a final completed record.

With the detailed analysis, as accumulated in this manner, the engineer can make a complete statement in minute detail or, if he prefers, in general terms, by combining several analogous classifications.

There are many other accounting phases which the writer has not mentioned herein, as the purpose is to treat of a method of cost keeping. Any accountant can fit the general plan above described into a well-organized bookkeeping system.

George Hill, M. Am. Soc. C. E. (by letter).—Every member of the society who presents a workable solution of a problem, and especially one of such importance, is entitled to the thanks of the members for so doing, and therefore the writer feels that on so important a matter as cost keeping Messrs. Falk, Hammatt, and Low have done well to contribute of their experience.

The attempt has frequently been made to solve the problem in


FOLIO
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
7-530
GENERAL CLASSIFICATION SHEET
MONTH OF ____ 190
FOLIO ____
DATE
0
1
2
3
4
5
6
7
8
9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Freight and handling
Time book distribution
Direct charges
Journal Vouchers
TOTALS
6-747

Standard Size of page, 8 by 10½ in.

FIG. 212.—General classification book, U. S. Reclamation Service.

some conventional or semi-conventional manner, usually without success, for the reasons that there existed:

(*a*) A lack of appreciation of the requirement for simplicity;

(*b*) A lack of appreciation of the fact that the information required is a combination of figures and the combinations are constantly changing;

(*c*) The general belief that cost keeping is something different from bookkeeping, instead of being intelligent bookkeeping.

If the accounts of any piece of work can be kept so as to meet, on the one hand, all the requirements of bookkeeping, and, on the other hand, all the requirements of cost keeping, the problem is in the way of being solved.

The real and only purpose of bookkeeping is to show the receipt and disbursal of money in an accurate manner. If this is performed so that, with a minimum of clerical work, clerical and arithmetical errors can be readily detected and eliminated, it is good bookkeeping.

When the next step is taken, and the memoranda of disbursal show for what the disbursal was made, this is beginning cost keeping.

If this is done in sufficient detail and in such a manner that the summations of two or more groups can be readily combined, the problem of cost keeping is solved.

If vouchers, checks, and bills are arranged so that they can be readily examined and compared with the entries, this provides for an accurate and inexpensive audit, and meets completely all the proper requirements of bookkeeping, cost keeping and auditing. The writer would emphasize the word "proper;" there are in use systems which are very complete but are so burdensome that the facts cannot be recorded and transcribed until long after their usefulness has vanished, and they are so full of detail as to blind the mind completely to their true significance. Knowledge of costs should be a weekly matter, and action should follow promptly.

It is a good thing to know that concrete 5 in. thick, placed in forms, cost on a certain job an average of 20 cts. per square foot, but it is more important to know that Brown's gang laid it for 18 cts., while, with Smith's gang, it cost 22 cts., under the same circumstances.

While it is possible to predetermine the general lines along which costs will be required, two-thirds of the questions asked

in regard to costs will call for summations of items other than those originally contemplated, and the same question will rarely be asked twice; consequently, the problem which the writer has attempted to solve is not a simple one. He has been engaged for many years in executing work on a fixed profit basis, and has had experience with the accounting systems of a wide range of clients, and, as a consequence thereof, has been compelled to devise a system of his own. Practical experience with this system has demonstrated its applicability over a wide range of subjects in a satisfactory manner. It is hoped that a description of it will be of interest to the society.

Although the system presents a method of keeping the exact cost of a piece of work, and is therefore in the nature of bookkeeping, it is not bookkeeping in the conventional sense, but an orderly arrangement of memoranda which are kept so that any cost question which may be asked during the progress of the work, either of a detail or of the entire work, can be answered, either immediately or in a few minutes. The memoranda are kept so that, if there are a variety of jobs in the office, each one is separate and distinct in its entirety; finally, they are kept so that, as soon as a piece of work is completed, all memoranda in regard to it are immediately filed away and prevented from interfering with other work in the office.

The writer will describe the system as applied to building operations on a fixed profit basis, as in this way the principles involved will be understood, and concrete examples may be more easily obtained.

1. Each piece of work is given a designating job number, and the estimate of original cost is entered in a monthly statement in a column headed "Original Allowance." In making up the estimate, the details of work, comprised under each account subdivision or number, are worked out in full, so that the cubic yards of excavation, and the incidental expenses thereof, are clearly stated.

In a column headed "Structural Steel," the number of tons of each of the various classes of steel, cast iron and other work, the price for the fabricated material, and the erection costs are stated, and so on down the list.

The sum of the statements in the column headed "Original Allowance" gives the total cost of the work, and these items are carried along in the monthly statements.

Any changes involving cost alteration are entered in a column headed "Additions." These additions appear in this column only for the month to which they refer, and in the following month are transferred to the "Original Allowance" column, leaving the "Additions" column free for the current month's changes.

The column headed "Payments" contains the summary of the disbursements under the various accounts to the date of the statement, and shows the total cost of the work to date. The sum of the payments plus the balance on hand in the bank (which is stated on blank lines at the bottom of the sheet) must equal the sum of money advanced or set aside for the conduct of the work.

All obligations incurred, either in the nature of sub-contracts, contracts for materials, and the like, are entered under the heading, "Contracts Made;" the column headed "To Complete" is only used occasionally, usually as the work approaches completion, for the guidance of officers or others who are not sufficiently familiar with all the details of the work to be able to supply the figures without assistance. It is rarely used more than three or four times on a job, but by being inserted in the monthly statement makes an additional form unnecessary.

2. The time is kept in duplicate by using one or more time sheets as may be necessary, and making a carbon copy. The sheets are made up in pads, kept in an enameled leather case, and each week the originals are sent to the office.

The columns, "Total Hours," and "Amount," are usually filled in by the superintendent and checked at the office.

The pay roll for each account number, as given in the monthly statement, is kept so that one man's name may occur several times on the pay roll. The only disadvantage connected with this is that sometimes two pay envelopes are made out in the same name, the sum of the two being the correct amount earned.

In the writer's work, weekly pay rolls amounting to $1,500 require 2 hr. time to check, draw the money, place it in the envelopes, and prove the accuracy of the distribution.

3. Materials in general are provided for either in connection with sub-contracts or by agreement with supply houses. If delivery is to be made complete at one time, and the time is determined, one of the orders is issued; but if delivery is to be made piecemeal, or at different times, two or more orders are issued, and these are subdivided so as to secure each delivery at the

time when it will be needed. The order is made out in quadruplicate, the order blanks being made up in pads and in sets of four, so that, by the use of carbons, one writing suffices for the four.

The first or white copy is to be retained by the party receiving the order, and on the back of this the conditions of the order are printed.

The second, or pink copy, is a delivery receipt. It is sent with the order when delivery is made, is signed by the job superintendent, and, when the bill is rendered, is attached to the bill and affords a means of checking it.

The third, or blue copy, is sent to the job superintendent as a notice to him that the order has been placed. As soon as the order is delivered, he signs the blue copy and returns it to the main office, where it is filed temporarily and is an evidence of a debt which should be paid on the first of the following month.

The fourth, or yellow copy, is retained in the office for purposes of comparison with the other copies and as an evidence of an outstanding obligation.

This procedure is followed in all cases except for bricks, sand, broken stone, cement, and loads of rubbish, in which cases slips printed on stiff paper are issued, and are dated with an indelible pencil by the superintendent when issued. These slips are returned with the bill, and, after the bill is checked and audited, are destroyed.

The blue and yellow order slips are kept in the same file, and are usually arranged in groups, so as to be readily reached. When the pink order slip comes with the bill, the blue and the yellow copies which correspond are removed from the file and, after comparison, are crossed off, then the three slips are placed in a file for paid orders.

The order numbers are endorsed on the bill and, if necessary, are grouped under the account numbers so that the bill is separated into its component accounts.

4. Small sub-contracts are treated the same as orders.

5. In reference to payments, each job executed is conducted as an independent piece of work, the agreement with the owner providing that, from time to time, he shall furnish the funds necessary to conduct the work. The funds are deposited in the bank to a separate account. This is done because the only effective control that can be exerted on work is the control of the purse strings; that certifying to the owner that payments are due

is very far from being the equivalent of a payment, and, finally, that where the builder's own capital is used for the conduct of the work, a charge would necessarily have to be made for such use, which would result in an increase in the cost.

The bank check used for this purpose is twice the width of an ordinary check. It is filled out so that the charge against the proper account number will appear on the face. The checks are carboned when written, so that an exact copy remains in the office. The check when issued is folded longitudinally, is endorsed in the customary way, passes through the bank as an ordinary check, and, although several thousand have been used with different banks, has met with no objection.

The check form is a typical pay-roll check. When a payment is made, the check number is endorsed on the bill or voucher, and the bill or voucher is filed in a Shipman file in numerical order.

6. In keeping the records, the writer uses a 9 by 13½-in. Shipman Common Sense Binder; heavy manilla sheets, with canvas tags bearing the account numbers, are used to separate the accounts, and regularly ruled ledger sheets are interposed between them for each account, as many sheets being used as are necessary. Additional sub-divisions are provided for recording the checks issued, called the "Cash Account," and for binding in the monthly statements. In small jobs, provision is made for binding in all contracts, sub-contracts, and additional orders received from the owner. On large jobs a separate binder is used.

The cash account sheets are regular ledger sheets, one-quarter of the upper left side of the page used for the entry of money received. The remainder of the left side of the page is used for entering the checks, with date, number, name of account, and amount. The right side of the page is used for keeping a running balance. This serves two purposes, the balance on hand is always immediately evident, and the sum of the checks to date, obtained at the end of each month, must show a balance equal to that obtained by the partial steps, thereby proving the arithmetical operations. Each check is entered in detail in the detailed accounts, the first page usually being devoted to labor, and the succeeding pages to materials and small contracts. Entries are made in the detailed accounts showing obligations incurred, where contracts are made for specific amounts, and these are entered on the left half of the page. Where checks are drawn

to pay the bills, the entry on the left half refers to the bill, and the payment is entered by date and check number.

The sum of all the entries on the right side of all the pages must equal the total payments to date. These summations are usually made lightly with a soft pencil at the foot of the page, and are carried ahead for each account, so that the last page of the account shows the total amount paid thereon. The monthly summaries of the larger divisions of each account are made in ink, so that a simple subtraction or the addition of three or four sets of figures will always give the month's business, for that particular item. The bank book is written up each month, and, as no payments are made except by check, the bank balance should correspond with the balance shown in the accounts, which, through the bank, proves the accuracy of the total payments made, and this gives an amount which should be the total of all the detailed accounts. Comparing month by month, as given in the monthly statement, the progress of the work is evident.

The writer has made it a practice always to prepare his own pay-roll checks, and to visit the work at least weekly. Writing out the pay-roll checks serves to fix temporarily the cost of the preceding week's work in the mind, and if a man is experienced in doing work, he can tell at once whether or not for that week's work he has received proper value for the wages disbursed. In the writer's experience, that is the best time to correct a foreman or a superintendent, because there is then likely to be little dispute as to the facts. This prevents the continuance of errors of organization, and shows where the ax should fall.

Generally, order slips and folded checks are of the same size, and all blanks are of conventional file size, so that anyone of the filing system cabinets may be used. The cost of the work may be determined within a small fraction of 1% at any time by an examination of the file. Each file is independent for each job, and can be taken away for study, or the entering can be interrupted at any point without difficulty.

All receipts, cancelled checks, and paid bills are filed in a similar Shipman's file, so that on the completion of a job the entire records may be filed. The space required for a $250,000 building operation is about 9 by 14 by 12 in. By the use of the forms in this particular way, duplicates are obtained of orders, checks, pay rolls, and monthly statements, carbons being an ex-

tremely important factor in saving time. On a $250,000 job the average monthly cost for all entering, bookkeeping, checking of pay rolls, and the preparation of monthly statements was 16 hr. at 35 cts., or $5.60.

B 22

Hull Division, Navy Yard, Phila.,Pa.

To ROUTE SHEET Date 10-2-6

J. O. 0225

Plan No.

Brief of Job

40 TON CRANE - QUARTERLY INSPECTION.

10-2-16

LL 10-10-16

PS 10-10-16

Approved	Started	Completed
Superintendent		Foreman

Section No. and Shop	SECTION	Date to Complete	Date to Start
1-LL	0225 FALLS	10-10-16	
	Was outside surface of fall cleaned for examination?		
	Were any wires in the strands broken?		
	Was the lay of the rope irregular?		
	Does the fall show any signs of kinks?		
	Does the fall show any indication of weakness?		
	Are the wires in the rope much worn? Or chafed?		
	Was the splice at standing part of fall examined?		
	In what condition found?		
2-PS	0225 BLOCKS	10-10-16	
	Were upper and lower blocks examined?		
	In what condition found?		
	Were straps and securing bolts of upper blocks examined?		
	In what condition found?		
	What is the condition of all sheaves?		
	Was topping lift gear examined?		
	In what condition found?	2	Sheets, Sheet No.
	Was hoisting gear examined?		
	In what condition found?		

FIG. 213.—Quarterly inspection blank for 40-ton shipyard crane.

As described in detail above, the system appears cumbersome; in practical working, it is simplicity itself, as is evident by the time and cost of keeping it up.

Route Sheet as Inspection Report.—In the September, 1917 issue of *Industrial Management* the forms, Fig. 213 and Fig. 214 were taken from an article by Wm. M. Kennedy.

Similar forms may be advantageously used by a contractor

B 22 Hull Division, Navy Yard, Phila.,Pa.

J. O. 0225

Plan No

To ROUTE SHEET Date

Brief of Job

10-2-16

Approved Superintendent | Started | Completed Foreman

Section No. and Shop	SECTION	Date to Complete	Date to Start
PS	Were all wheels and trucks examined?	10-16-16	
	In what condition found?		
	Was roller rack examined?		
	In what condition found?		
	Was king bolt examined?		
	In what condition found?		
	Were all pivots and pivot plates examined?		
	In what condition found?		
	Were hinge pins examined?		
	In what condition found?		
	MECHANICAL		
	Were all journals and boxes examined?		
	In what condition found?		
	Were all gears examined?		
	In what condition found?		
	Was topping lift and nut examined?		
	In what condition found?		
	Were all clutches and levers examined?		
	In what condition found?		
	NOTE: All route sheets are to be returned on completion to Pl. Rm. Via. Shop Supt. with M.R.Ss for work to be undertaken.		Sheets, Sheet No.

FIG. 214.—Inspection blank used at Philadelphia Navy Yard.

operating any large piece of equipment, for instance as steam shovel or drag line, and thereby provide a means to check up the general condition of the machine before shipping it for work in a locality where repairs might be difficult or expensive.

The questions applying to the machine considered may be typed in as shown in the illustration and by having each one answered by the inspector reasonable assurance, that the equipment is in practical working condition, may be expected.

Loose-leaf Balance of Stores Sheet.—A loose-leaf balance of stores sheet is also described by Wm. M. Kenndey in *Industrial Management* September 1917.

This form, Fig. 215, designed for use in a shipyard is used in connection with material bin tags. It acts as a double check on

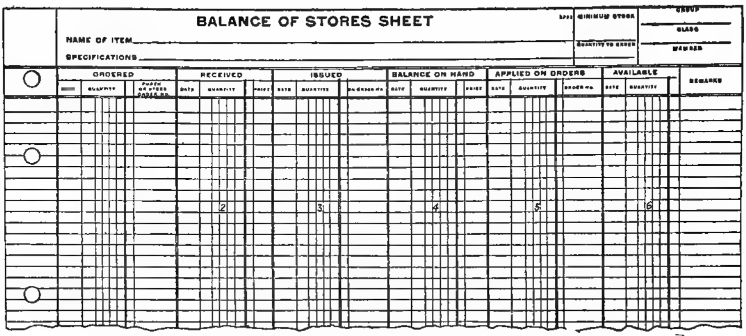


FIG. 215.—Loose leaf from balance of stores ledger.

stores and with it the store clerk is enabled to determine in a moment the quantity of an item available and on hand. When material is ordered it is entered in the first column; when received it is added to the amounts in columns 2, 4 and 6; when reserved for work in course of manufacture, but not immediately required, it is added to column 5 and deducted from 6; when material reserved in column 5 is issued it is deducted from 5 and 4; material under 6 is available for use, not reserved or applied on orders.

CHAPTER X

SYSTEMS OF COST KEEPING

Cost Accounting on Construction Work—Detailed Description of an Efficient System.—The following appeared in two sections in *Engineering and Contracting*, April 8th and 22nd, 1914.

Contractors in general have made some advance in recent years as regards their methods of cost keeping and of analyzing cost data, but the systems used in most cases are not comprehensive enough, nor is enough attention given to them to render them of greatest value. We believe that contractors will adopt better cost keeping and cost analysis systems as soon as they are brought to a realization of the importance of this part of the work. It must be realized at the start that no comprehensive system will be effective unless the contractor is willing to follow it up closely and give it skilled supervision. Contractors should know what various parts of the work are costing in time to enable them to modify inefficient methods, and the system which merely gives the costs of various items of the completed work has little value. The following paper, by Leslie H. Allen of the Aberthaw Construction Co. of Boston, presented before the Boston Society of Civil Engineers, gives in detail the cost accounting system used by this company on construction work. We have largely re-arranged the data contained in the original paper, but shall publish it practically in full.

General.—The problem of cost accounting on construction work is one that has not received the amount of attention and study that its importance warrants. When we consider the vital importance to the contractor on construction work of a knowledge of the cost of his work, it is surprising to find that only a few contractors have succeeded in finding out in detail what the unit costs of their work are. Most of the big commercial enterprises make a point of figuring very carefully their cost of production, but building and engineering contractors seem content to go on in their old ways, with only a hazy idea how their work is coming out, and no definite knowledge as to the

amount of profit or loss made until the job is completely finished and paid for. I venture to assert that not more than 10% of the contractors in Boston doing work on a lump sum basis could tell within $1,000 what their profits or losses are on their unfinished contracts now in hand.

It is not hard to find a reason for this state of affairs. The old-time superintendent of construction was usually a mechanic who by reason of special ability had risen to the command of men and become a superintendent. These men, of whom many are still with us (and doing excellent work), are men to whom figures and costs meant very little. They relied for success on their innate common sense and their ability to drive the men under them, and although they made mistakes, some of which would have been self-evident if they had studied costs carefully, yet they did excellent work and achieved results not to be despised even in these days of scientific management, cost accounting and complex organizations of one sort or another. Such men, however, took no interest in cost accounting, and if directed to furnish cost figures took very little care to see if they were made up rightly or not.

Another reason is that there is often a lack of definite instruction given from the office as to how costs are to be kept, and that no man who has studied the problem and knows definitely just what is wanted is in charge of the work and personally responsible for it. The timekeeper on a construction job is a very busy man. Often he has materials to order and check, and many other duties to perform, and has no time to think out the details of a cost accounting system for himself, and he contents himself with as little work in subdivision of pay rolls as his experience tells him will "get by." Then when his reports come in they are handled by clerks who do not understand them and who do not make any effort to correct them as they go through, and the cost accounting system becomes unreliable and one is told that "it is impossible to keep accurate costs on construction work."

It is probably true that every contractor and builder has made some attempt to find out the unit costs of the work which he does. Some contractors have got a system that really gives them the information they need. Many firms have a cost keeping system which tells them approximately what their unit labor costs from week to week are, but takes no account of materials and gives them no idea as to how the whole job stands financially. Such

men have no real idea as to whether their jobs are profitable or not until the bookkeeper's statement at the close of each job shows the actual profit or loss made. Many have tried to keep up a cost keeping system, but have thrown it up owing to its difficulties and inaccuracies, and rely simply on their bookkeepers to tell them how much expense has been incurred on the job, while their eye tells them how much of the job is done. The writer remembers in his earlier days being directed to visit half-completed jobs for which he had made the estimate and make a survey of same for comparison with the bookkeeper's statements, and this was the only way known by his firm at that time of comparing estimated costs with actual costs to see what profit or loss had been made, although at that time a system of reporting weekly costs was being used similar to that outlined above.

With the change of the times and the change in contractors' methods, the attitude of the contractor to cost accounting systems is changing, too. The old-time superintendent is giving place to the technical graduate who is a man with engineering training accustomed to view the situation from all sides and relying on actual cost figures rather than on his own judgment to tell whether his work is efficient. Modern competition is becoming so keen and work is taken on such a small margin of profit that it is of vital importance that every item of the work be kept down to its estimated cost, and cost keeping is fast becoming a necessity to all who wish to make a profit out of contracting on construction work.

The purpose of any cost accounting system is threefold: First, to watch the job from week to week to see if the work is being carried out economically; second, to see whether the cost is above or below that of the original estimate; and third, to furnish information for future use in estimating and in supervising work in progress. In other words, first, to determine the items of prime cost and the unit prices of these items; second, to discover what relation these bear to a predetermined selling price; third, to establish new selling prices for future work. The relative importance of these three items is in the order given.

The problem before the contractor's accountant is an entirely different one from that of the bookkeeper or the factory cost keeper. A good deal of the dissatisfaction and incompleteness of many existing systems is because the problem has been approached from the financial point of view rather than the

engineer's. I think it was Mr. R. T. Dana who was the first to insist that cost keeping was not a bookkeeper's job and could not be satisfactorily handled by the man who kept the firm's books. This is so. The bookkeeper's viewpoint is the financial one, and deals with totals and balances of cash. The cost accountant's viewpoint is an engineer's, and deals with unit costs and quantities of materials. The two cannot be satisfactorily held by one man unless he has had a thorough training both in bookkeeping and engineering lines. Such a training is rare. The primary object of the cost keeper in a large factory or mill is to determine the selling cost of the articles, and therefore every item of expense burden incurred in carrying on the factory is prorated or apportioned to the cost of the articles produced for sale. The contractor's selling cost is determined beforehand and he is faced with the problem of so splitting up his selling cost that he has a proper appropriation for each item of expense, the very reverse of the factory's accountant's problem. It is for this reason that I have placed prime cost first as being the most important, and selling cost last as of least importance.

The estimate of cost on which a contract is taken is more like the budget appropriation of our government, which having a predetermined amount of money to spend proceeds to allot as much as is possible to each government department in proportion to its needs, the total of such appropriations being equal to the amount of the estimate of cost.

The contractor's cost accounts, if they are to be of any use, must show not only the amount of money spent in the work, but the way in which it has been spent; and this can not be shown if items of general expense, such as plant, watchmen, etc., are all distributed among the items of excavation or concrete. The result may be financially accurate but uninforming to the contractor. For instance, on the cost accounts on the Panama Canal which appear in the *Canal Record* it will be noted that the cost of plant, track forms and general expense, etc., all are worked out in terms of per cubic yard of concrete. This is correct from the financial viewpoint, and the result shows the cost of the concrete to the government. But it does not tell an engineer whether the work is being done efficiently or not. He wants to know the cost of setting up and repairing the plant, the cost of handling the material, the detailed cost of form work, while general expense is meaningless to him unless he knows the

details. When the cost of moving tracks, repairing plant, etc., is reported at so much per cubic yard as a subdivision of excavating cost, the cost of the operation cannot be criticised. It is very necessary that this distinction be kept in mind and that costs should be worked out from an engineer's standpoint rather than from a bookkeeper's or an accountant's standpoint. The information turned out by the cost-accounting department should not only show results but should give information showing the reason why the results are so.

In the writers' judgment, the cost accounting on construction work should be handled in connection with the estimating department rather than in connection with the bookkeeping department. The estimator should know best what information he requires from a job to check up the work he has estimated, and into what units the costs should be divided. He is then enabled to keep closely in touch with actual work in progress and to compare it with his estimate from time to time.

The method usually employed by contractors in their cost accounting is to divide up the time spent on the job under certain fixed headings, such as excavation, brick work, mason work, concrete work, carpentry, and so on, and to make a report of the quantity of each kind of work executed, and to work out from same either daily or weekly the unit labor costs; at the close of the job, to work these up into totals and also to work up at this time the cost of all materials into units and combine them with the labor costs, giving the total cost of labor and material on each item of the work. This works well in some offices as far as it goes, and shows whether each week's work was efficient and economical. But if no account is kept of material until the job is closed, and no check is taken on quantities reported by the men on the job, and no comparison is made with the estimate, its value is not very great. In the system used by the Aberthaw Construction Co., we have added from time to time the following features which do not appear in most accounting systems. First, in addition to the weekly labor costs, the average labor cost on each item to date is figured. Second, a periodical check on the quantity report is made. Third, we use a standard mnemonic code revised to suit the requirements of each job. Fourth, an accounting of material is kept up from month to month. Fifth, an analysis of the estimate is made for comparison with the weekly costs. Sixth, a monthly balance is struck, showing

profit or loss to date. Seventh, a "field sheet" is furnished to the timekeeper which enables him to keep track more regularly and systematically of the men at work.

It is the purpose of this paper to describe the Aberthaw company's system in detail, taking up in logical order the above points and matters incidental thereto. The present system was not invented in a day but has been a gradual development. The cost keeping system was installed early in the history of the company by Mr. Wason, the president of the company, who laid work out upon the usual lines adopted by other contractors as indicated above. The above additional features have been added since the beginning of 1910 in the order indicated above, and the complete system may be said to have been in working order for over 2 years, long enough for us properly to try it out and to know that it really gives us the information we need. In other words, the system I am about to describe is not the dream of a theorist, but something that is really practicable; that is not expensive in operation and that any contractor can use if he has but the patience to study his problem and insist on getting just the results he wants.

Although the writer's firm specializes in one branch of construction work the system is equally applicable to any other work of similar nature, whether in the line of heavy engineering or the building of modern office buildings or frame dwelling houses.

Section I.—The Analysis.—At the start of a job, an estimate is made of its cost in the usual way. This estimate is then analyzed to show its component costs. Figure 216 shows an estimate on a small job executed by the Aberthaw company this year. Figures 217 and 218 show the analysis of the same. This analysis is almost self-explanatory but it will be well to call attention to one or two points in it. It will be noted that the seven items of concrete and finish in the estimate have been resolved into 19 items in the analysis, and the seven items of forms in the estimate have been resolved into 11 items in the analysis, and so on, each item being resolved into its component parts, and where these parts are alike in two items adding them together. For instance, concrete labor in footings appears by itself, but the cement, sand and stone are added to those in the columns and floors. By adding together, it will be found that the seven items of concrete in the estimate have the same total cost as the 19 items in the analysis.

This analysis is used as a basis of comparison during the life of the job, and the original estimate is not referred to at all. This is different from the general practice, as it is usual to build up the units of labor costs on a job in a synthetical manner to

Estimate No. 1210 **ABERTHAW CONSTRUCTION CO., BOSTON** Sheet No.
Job No. 1990

Summary of Estimate

May 17th 1913

Concrete footings 1 2½ 5	246 cu. yds	6.00	1476
. columns 1 1½ 3	169 . .	7.50	1268
. floors & wall beams 1 2 4	690 . .	6.60	4554
. window sills	629 ft. l.	25	157
Cinder concrete crickets on roof			25
2" Cinder concrete fill between screeds	20940 sq. ft	03	628
Rubbed external finish on concrete			300
Forms to footings	4573 sq. ft	10	457
. . internal columns	3037 . .	15	456
. . external columns	7300 . .	15	1095
. . internal column heads	* 70	4.50	315
. . external columns brackets	* 55	1.00	55
. . mushroom floor slabs	28618 sq. ft	10	2862
. . wall beams	3918 sq. ft	12	478
. . window sills	629 ft. l.	20	94
Steel reinforcement, plain round bars. base sizes	20 Tons	43.00	860
¼" slab bars	21 .	48.00	1008
Sundry steel	5 .	46.00	230
¼" spirals	2½ .	80.00	200
Inserts	* 1000	15	150
Rivetted bearing plates in footings	* 17	3.00	51
Brickwork 8" curtain walls in Flemish bond	1200 ft.	.55	660
Cutting toothing & patching old walls adjoining			50
2" Wire lathed & plastered both sides partition	18 sq. yds	3.00	54
Hard pine posts framed in to support old building	2 M	80.00	160
Repair old floors where old building adjoins new			250
Pine Stairs & enclosure 1st Floor to Basement			35
Pipe railing			50
Miscellaneous cast iron work			436
. wrot iron & steel work			341
Tinned doors & hardware & erection.	* 2	30.00	60
Steel sash including glass and glazing	5260	43	2270
erection of same		05	263
Excavation over site	100 c. y.	50	50
. for trenches for footings etc	553 c. y.	80	442
Spruce sheet piling to trench	10 M	50.00	500
Grading			100
Clean up the job and clean glass			100
Travel, board & superintendence			300
Liability Insurance			400
Contingencies & sundries.			400
Total Estimated net cost, excluding profit		$	23640

FIG. 216.—Summary of estimate.

compare with the estimate, rather than to analyze the estimate to compare with the units on the job. This is a very important feature of the system and is a solution of one great difficulty. The usual method is to try and build up the price of each item from the information on unit costs given, so as to compare it

with this item in the estimate. Take, for instance, the item of concrete. The price of concrete is compiled by reckoning up the labor of unloading cement, sand and stone and the cost of these materials, and also the labor of mixing and placing and finishing

Job No. 1990 ABERTHAW CONSTRUCTION CO. Sheet No. 1

Analysis of Estimate

		Labour		Materials & Sub Contracts	
Concrete					
Labour in footings	246 c.y.	1.00	246		
" " columns	169 "	1.50	254		
" " floors & beams	690 "	1.00	690		
" " window sills	629 ft.	.16	95		
" " cinder concrete brackets			20		
" " cinder concrete fill between screeds including laying screeds finished by owner	125 c.y.	2.00	250		
Rub with carborundum			300		
Plant erect & repair			250		
" dismantle			50		
" freight					150
" rental					300
" small tools & supplies					450
Cement	2000 bbls.			1.75-.40 +.135	2700
tests				.03	60
Unloading, teaming & loss on M.T.S.				.05	100
Sand	520 c.y.			.80	416
Crushed stone	1400 tons			1.40	1960
Cinders	130 c.y.			.50	65
Concrete sundries					52
Forms.					
Labour in footings	4580 sq.ft.	7.00	321		
" " floor slabs	28618 "	7.00	2005		
" " wall beams	3981 "	9.00	359		
" " external columns	7300	11.00	803		
" " column brackets	#55	.70	39		
" " internal columns & heads				Sublet	771
" " window sills	629 ft.	.15	94		
Lumber, nails, & oil etc.					1070
Unloading & handling lumber			50		
Sawmill			100		100
Detailing forms in Boston office					100
Steel Reinforcement.	46 Tons			37.00	1702
Spirals	2½			60.00	150
Tests					10
Unloading	48½	.50	24		
Wire & sundries				.50	24
Bend & place	48½	8.00	388		
Rivetted bearing plates in footings	#17			3.00	51
Inserts	#1000	.05	50	.10	100
			6388		10331

FIG. 217.—Analysis of estimate (continued in Fig. 218).

the concrete and the cost of the tools and plant. (I do not mention forms, which I regard as an entirely distinct and different item.) If at the end of a month 500 cu. yd. of concrete have been placed and material enough to mix another 600 cu. yd. is on the ground and all the plant is set up, it will be a very difficult matter

to determine exactly how much labor and material should be charged to work which is done and how much is chargeable to future work. If all the mason's staging is erected and only one-third the brickwork is done, the cost of brickwork will be

Job No 1990 — ABERTHAW CONSTRUCTION CO. — Sheet No. 2

Analysis of Estimate Cont'd

		Labour		Materials & Sub Contracts	
Brot forward			6388		10331
Brickwork	1200 ft	20	240	35	420
Cutting and patching old brickwork			35		15
Metal lathed & plastered partition			24		30
Hard pine posts			50		110
Repair old floors			200		50
Pine Stairs & enclosures			20		15
Pipe railings			[illegible]		40
Miscellaneous cast iron work			36		400
wrot			70		271
Tinned doors 2 including erection	# 2			30.00	60
Steel sash including glazing	5262 sq ft				2270
erection		[illegible]	263		
Excavation over site	100 c.y	50	50		
Excavation for footings	553 c.y	80	443		
Spruce sheet piling	10 M	15.00	150	35.00	350
Grading			100		
Clean up the job & clean glass			100		
Travel, board & superintendence					300
Liability Insurance					400
Contingencies & Sundries					400
			8178.		15462
Net Total			$ 23640		

FIG. 218.—Analysis of estimate (continued from Fig. 217).

unbalanced in the same way. To solve this difficulty we use an analysis of the estimate and keep the costs on each item of the analysis separately. The estimate is put away and never referred to again, and all comparisons are made with the analysis. You will see when I describe the monthly statement how easily

this takes care of difficulties like those referred to, or to unfinished work. It is not until the job is completed and the books are closed that I make a synthetical summary showing what a cubic yard of concrete or a cubic foot of brickwork has cost.

I lay stress on this because the difference between analysis and synthesis in accounting is vital, and it is my belief that it is not possible to get a clear and accurate idea of the fluctuations of cost on construction work by a synthetical method, because labor and material and overhead expense are so distributed that they cannot be properly identified or criticised. It will be noticed that labor and material are kept in separate columns in the analysis and are kept entirely distinct all through the job. For accounting purposes, material includes sub-contracts, insurance, traveling expenses, electric power, etc., and in fact everything except labor and teams. Teams when hired by the day are reckoned as labor, but teams working under contract, at an agreed price per load, per yard, etc., are reckoned as sub-contracts and kept in the material account.

On the work of most contractors it will be found that the amount and cost of the materials will not vary very much, and, except for checking consumption of cement, coal and lumber, the profit or loss made on materials at the start of a job will remain steady all through. But the labor does fluctuate exceedingly from week to week. It is on the labor side that most of the losses or profits may be expected. In this paper and in the writer's firm a good deal more attention is given to the labor side than to the materials. At the same time the material must not be overlooked, as wasteful use of cement, lumber, etc., may run the cost of a job up unexpectedly, to say nothing of the need of a periodical check, if there is any suspicion of graft among subordinates.

We furnish a copy of the analysis in notebook form to the superintendent on the job as well as to our general superintendent and to the heads of the firm. This is particularly useful to the job superintendent, as he knows what the office expects him to accomplish in the way of costs. If his judgment on costs is not sound, it tells him what the items of his work ought to cost.

Section II.—The Code.—Having analyzed the estimate, instructions are made out for the timekeeper in the form of a code, which is shown in Table 14. This code is made up from

the standard mnemonic code used by the author. The code differs from that used by other contractors only in the fact that the mnemonic principle is used instead of numbers, and that the divisions of time have been carried a good deal further than is usual. Although this does not seem to be an important item in itself, it is so because it simplifies the work of the timekeepers on the job to a very large extent, and insures more accurate and intelligent reports being made from the job.

Table 14.—Standard Timekeeping Code

Main Divisions—Kinds of Work

Initial Letter:

P Plant.
D Digging, earthwork and rockwork, and items in connection.
M Concrete.
F Forms.
R Reinforcement.
K Finish of concrete surfaces.
C Finish carpentry (windows, flooring, etc.) and any carpentry not belonging to P, D or F.
S Miscellaneous steel and iron work and other metal work.
B Brick masonry, stonework, tile, Akron pipe, etc.
Z Miscellaneous.
X Extra work (prefix to any of above).

Subdivisions—Kinds of Labor

Second Letter (for all main divisions except D and K):

a Making or preparing, *viz.*, making up forms, mixing concrete, bending or fabricating steel, etc.
e Erecting, placing or building, *viz.*, erecting forms, placing concrete, laying brick, fixing sash, etc.
i Removing, stripping or cutting away, *viz.*, stripping forms, cutting away concrete or brick, etc.
o Repairing, *viz.*, patching voids in concrete, repairing mixer, etc.
u Receiving, unloading, piling, loading, etc., *viz*, receiving cement, sand, lumber, etc., unloading and storing same, unloading plant and reloading at close of job, etc.

Second Letter with D:

a Excavate.
e Backfill.
i Pumping.
o Grading.
u Drilling and blasting.

Second Letter with K:
a Picking.
e Plastering.
i Rubbing with carborundum.
o Repairing, filling voids, cleaning floors, etc.
u Granolithic finish laid integral with the slab.
ua Granolithic finish laid after concrete has set.
y Cement wash.

Subdivisions—Location of Work in the Building

Third Letter (for all main divisions except P, S and C):
b
bc Belt course.
c Columns.
ch Column heads (mushroom).
cc Cinder concrete.
d Footings.
dp Drain pipe (tile).
f Floors.
fs Floor slabs.
fb Floor beams (beam construction).
fm Corrugated metal to slabs.
g
h Cellar or basement.
j
k Cornice.
l Lumber.
m Monitor or pent house.
n Lintels.
p Paving or sidewalk.
q
r Rubbish.
s Stairs.
t
v Vault lights.
w Walls.
rw Retaining walls.
ws Window sill.
cw Curtain walls.
x Cement.
y Sand.
z Stone or gravel.
Third Letter with C:
c Column.
d Door.
df Door frame.
dt Door trim.
f Floor.

fb Floor beam.
fs Floor screed.
fp Sub-floor plank.
ft Top floor maple.
g Gates.
h Hardware.
ho Operating gear.
j
k Cornice.
l Lumber.
m Monitor or pent house.
ms Monitor sash.
n Lintels.
p Partition.
pl Platform.
r Roof.
rb Roof beam.
rp Roof plank.
rt Roof truss.
s Stairs.
t
v
w
x
y
z Miscellaneous.

Third Letter with S:

b I-beams, channels, etc.
c Columns.
cb Column bases.
d Doors.
dg Door guards.
df Door frames.
ds Door sills.
fl Flashing.
g
h
j Bolts.
k Cornice.
l
m
n Lintels.
p Pipe.
q
r Railings, gratings, etc.
s Stairs.
sr Stair rails.
sl Sleeves.
t Trusses.

v Inserts for sprinklers, etc.
w Windows.
ws Window shutters.
wg Window guards.
x
y
z Miscellaneous.

Third Letter with P:

b Boiler.
c Crusher and elevator.
ch Chute.
d Derrick.
f
g Locomotive, portable engine and boiler.
h Hoisting engine.
j
k
l Elevator tower, bucket and hoist.
m Mixer and engine.
n Temporary buildings.
p Pump.
q
r Runways, staging, ladders and guardrails, etc.
s Wood-working shop, saw bench, planes, etc.
t Track.
v
w Water supply.
x
y
z Miscellaneous.

All contractors who have attempted any cost keeping will agree on the necessity for some sort of a code to report work done, not on the ground of secrecy but to obtain concise, quick descriptions. It has been found that if timekeepers are simply told to report the work done and describe it, their descriptions will be misleading and verbose, and in going their rounds they will probably make up a code for themselves which afterwards they have to turn into a written description.

It may be worth while to spend a little time in explaining the principles of the mnemonic code used. The initial letter is always a capital and indicates the kind of work to be done. For instance, "M" stands for Concrete Masonry, "F" for Forms, "R" for Reinforcing Steel, S for Structural Steel and Miscellaneous Iron Work, "B" for Brickwork, and so on. As far as possible the initial letters chosen are mnemonic, that is, they are the first

of the items they represent. The second letter is always a letters vowel and indicates what is being done in the division of work which it is describing; "a" stands for making items before setting, and "e" stands for erecting or setting or fixing in place; "i" stands for stripping or removing or pulling down; "o" stands for repairing or patching; "u" is a general utility item standing for unloading and other similar items. It will be seen that these are mnemonic in that each vowel is the vowel sound of the word that it represents. The third letter, which is always a consonant, indicates mnemonically the place or part of the building in which the work is done; that is, "f" indicates floors, "c" columns, "b" beams, "k" cornice, "l" lumber, "d" doors, and so on. As far as possible these are mnemonic, but it is not possible to make every item so, and some consonants have to be arbitrarily chosen to make out. As the standard code is the same on every job and is used simply with adaptations to meet the requirements of the work in hand, these arbitrary symbols are quickly learned. It will be noticed that the third letter has be a different one in the case of items relating to plant.

It should be an easy matter to revise this code to apply to any other sort of construction work, or to industrial work of any kind, bearing in mind the general principles on which it is framed.

Although at first sight it looks complicated, yet it has been found to be very simple in practice, and new timekeepers and superintendents very quickly pick up its essentials.

It has the advantage that if any work is done on the job which was not known of or contemplated when the original code was made out, it is a simple matter to adapt the letters and make up a fresh code word for the new work. As a matter of precaution, we always require our timekeepers to give the explanation of a new code whenever he makes one up, although very often we can read them without such explanation, owing to our familiarity with the principles on which the code is based.

From the standard code as given above a special code is written out in the head office for the job before the work is started, and from time to time additions are made from the office or by the job, to meet special items of work met with on the job; but all the main items of work, such as concrete in columns and floors, forms and reinforcement, have the same code word at all times, for example:

M—Concrete	Mix	Place	Fill voids, smooth up, etc.
Footings	Mad	Med	Mod
Floors and roof	Maf	Mef	Mof
Columns	Mac	Mec	Moc
Walls	Maw	Mew	Mow

F—Forms	Make	Erect	Strip
Footings	Fad	Fed	Fid
Floors and roof	Faf	Fef	Fif
Columns	Fac	Fec	Fic
Walls	Faw	Few	Fiw

Section III.—The Timekeeping.—(*a*) *The Field Sheet.*—On the job the timekeeper is supplied with what we call a "field sheet," an example of which is shown in Figs. 219 and 220. This field sheet is, we believe, an innovation in timekeeping. A fresh sheet or sheets is used every day and is carried around by the timekeeper on the job. In the left-hand column he enters the numbers of all the men who are at work, and it will be noticed that the tenth line is a heavy line and that numbers 10, 20, 30, and so on appear on these heavy lines always, and if necessary, blanks are left in between to insure this being done. (The object of this will be explained later.) After having checked the men in, in the second column from the left, the timekeeper starts on his rounds and in the column headed 7 to 8 he places against each man's number the code word for the work he is doing. On making his second round, which is usually about 10 o'clock, if the man is still on the same work he simply places a check in the intervening columns to show that the same work is going on. The timekeeper has to make at least four rounds every day and has to find each man on every round. If a man is not found, his pay is docked unless he can satisfactorily explain where he was.

It will be noted that the field sheet provides columns for checking the men in after the noon hour and for checking men out at night and for overtime. The last column is the total

number of hours worked during the day, which is used in making up the pay roll, as will be shown later.

In going his rounds, the timekeeper carries the field sheet in a stiff binder similar to that used by the express companies. On a large job, sometimes as many as six or eight sheets are used every

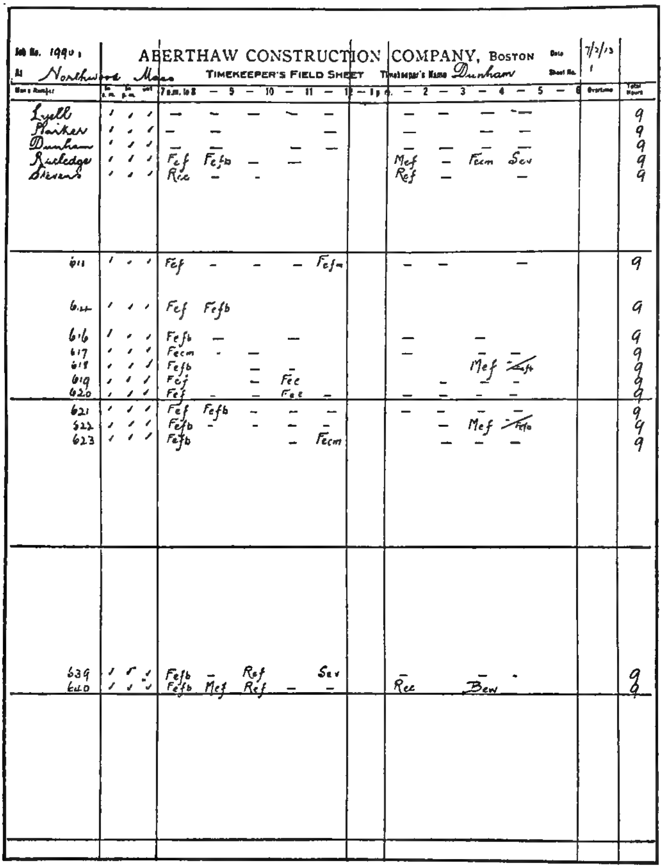


FIG. 219.—Timekeeper's field sheet (continued in Fig. 220).

day. They are, of course, all numbered up with the numbers of the men before he starts on his rounds. The advantages of this field sheet are as follows:

1. The timekeeper keeps a permanent record of what the men are doing every hour in the day. This is an improvement on the old method, when timekeepers used to take the time on old

pieces of scrap paper, backs of envelopes, or pieces of old board, and kept no permanent record of the work in any form. In that way men were frequently missed and their time afterwards guessed at, and there was no check on the men that showed they were all at work.

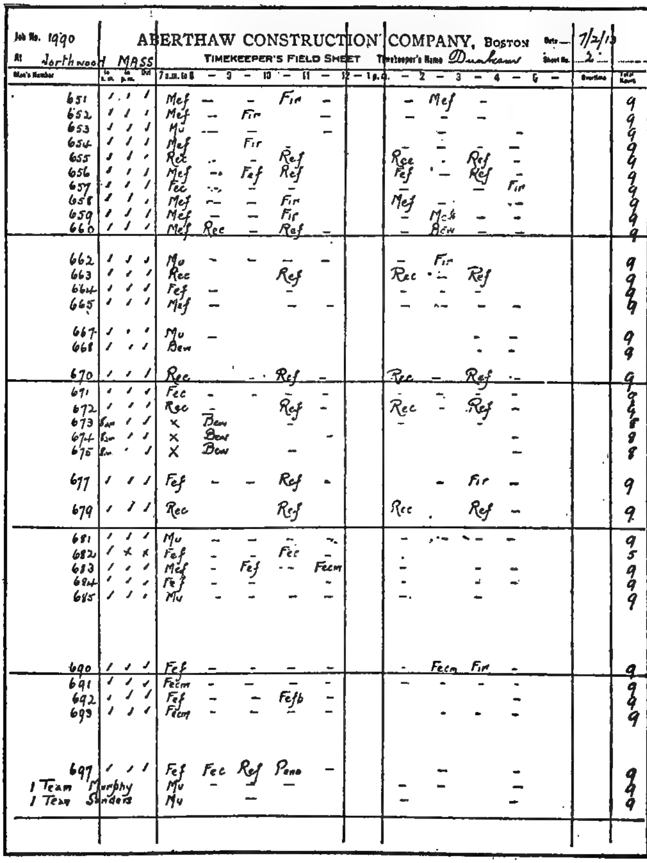


FIG. 220.—Timekeeper's field sheet (continued from Fig. 219).

2. The superintendent can easily check the work of a timekeeper. Most of our superintendents, each time that they go out no to the work, make a note of the numbers of three or four of the men and note what they are doing at that time, and on coming in refer to the timekeeper's field sheet to see what work he

has entered them as being on, and by picking out at random a few men every day in this way it is easy to find out whether the timekeeper is doing his work correctly.

3. It is easy to disprove men's claims for more time than they are allowed, as in addition to the record on the pay roll we have this actual check on what the men were doing hour by hour, and a man who claims his time is short is confronted with the field sheet, which shows exactly what he has been doing.

4. On a large job, two men can work together on the time-keeping, for on a job where the pay roll is as much as $4,000 a week it is all one man can do to go round the work and note the men's time. He turns in his field sheet to an assistant time-keeper, who makes out the pay roll and time sheets from it. Under the old methods, when rough notes were made on scrap paper, this would be a very difficult if not an impossible thing to get done correctly, and the result would be that the timekeeper's field work would suffer and the cost accounts would be inaccurate.

There are necessary limits to the number of subdivisions made in the work. Some timekeepers with more zeal than discretion will multiply subdivisions without end if not watched. It is a standing instruction to our men that the laborer who shakes out and bundles cement bags is to be charged to the largest concrete item of the day, and that the saw filer is to be reported on the largest piece of form work. All time on temporary dams for construction joints in concrete floors are reported with floors. The superintendent, timekeeper and water boy are not so charged, but are prorated on every item, as will be seen in Section IV (A).

(*b*) *The Time Sheet.*—Figures 221 and 222 show the daily time sheet. In this it will be noted that the ruling is the same as on the field sheet, with every tenth line reserved for numbers 10, 20, 30, and so on, so that the men's numbers appear always on exactly the same line on each sheet. In the left-hand column are the numbers of the men and on the top of the succeeding column are written the code words of the work in progress. Under these is entered against every man the number of hours he has spent on the section of the work denoted, and on the right-hand side is a column for the man's rate. The next two columns are headed "For Office Use," and when the sheets come into the office the total amount spent on each subdivision

of the work is worked up and entered there, as is shown in the example. The extreme right-hand column is reserved for the report of the quantities of the work done, which are entered by the timekeeper every day, or, in some cases where the work is unfinished at the end of the day, every second or third day.

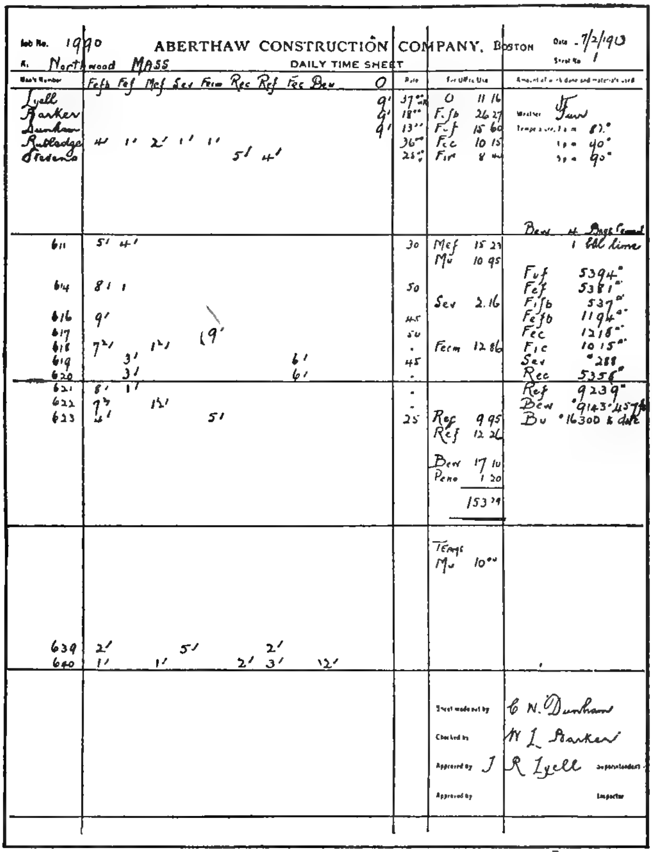
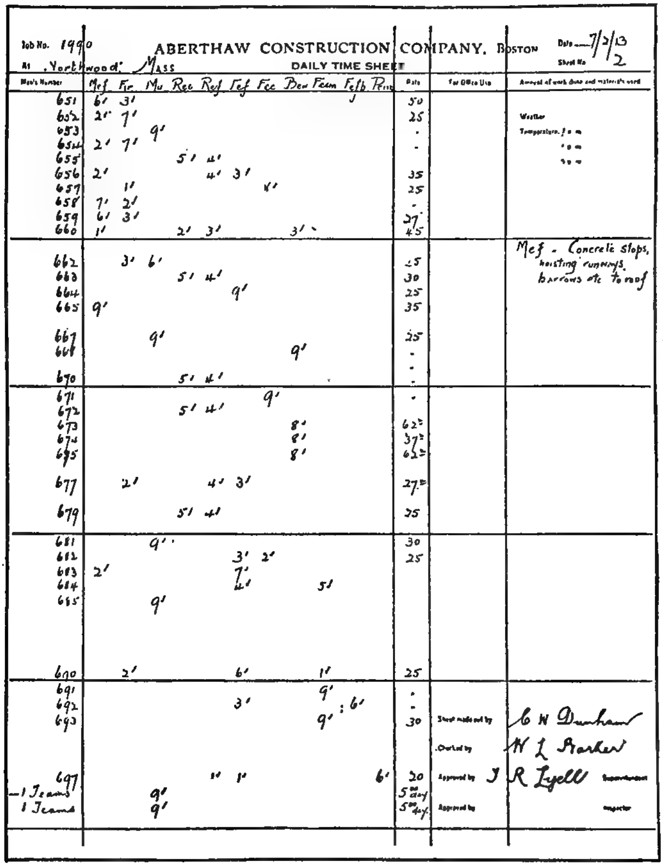


FIG. 221.—Daily time sheet (continued in Fig. 222).

These sheets are entered up by the timekeeper on the job, sometimes in the evening after the day's work is done, but usually in the morning following the day in which the work was done. They are mailed to the office daily.

(c) *The Pay Roll.*—Figures 223 and 224 show the payroll, which is also ruled up in sets of ten lines, like the field sheet and

the time sheet. This is similar to all contractors' pay rolls and needs no comment, except to point out the immense saving of time that has been made by the use of time sheets, field sheets and pay rolls, all ruled uniformly, and insisting on leaving blank spaces rather than using every line on the time sheets and pay


Job No. 1990 ABERTHAW CONSTRUCTION COMPANY, BOSTON Date 7/2/13
At Northwood, Mass DAILY TIME SHEET Sheet No. 2

Man's Number	Hours (Mef Fr Mu Rec Ref Fef Fee Den Fem Feb Rm)	Rate
651	6′ 3′	50
652	2′ 7′	25
653	9′	.
654	2′ 7′	.
655	5′ 4′	
656	2′ 4′ 3′	35
657	1′ 8′	25
658	7′ 2′	.
659	6′ 3′	27
660	1′ 2′ 3′ 3′	45
662	3′ 6′	25
663	5′ 4′	30
664	9′	25
665	9′	35
667	9′	25
668	9′	.
670	5′ 4′	.
671	9′	.
672	5′ 4′	
673	8′	62½
674	8′	37½
675	8′	62½
677	2′ 4′ 3′	27½
679	5′ 4′	25
681	9′	30
682	3′ 2′	25
683	2′ 7′	
684	4′ 5′	
685	9′	
690	2′ 6′ 1′	25
691	9′	.
692	3′ 6′	.
693	9′	30
697	1′ 1′ 6′	20
1 Team	9′	5 day
1 Team	9′	5 day

Weather / Temperature
Mef - Concrete stops, hoisting runways, barrows etc to roof
Sheet made out by C H Dunham
Checked by H L Barker
Approved by J R Lyell Superintendent
Approved by Inspector

FIG. 222.—Daily time sheet (continued from Fig. 221).

roll. The pay roll is filled in simply by placing the field sheet over the pay roll, and transferring the number of hours' work without even referring to the men's number. The pay roll is then checked by the time sheet, so that there is a circular check on the whole of the operation.

(*d*) *The Quantity Report.*—This has already been referred to when considering the time sheet. It is of course of vital importance that the quantities should be accurately reported. We make it the duty of the engineer in charge of the level and transit to compute the quantity of work done each day and turn

Job No. 1990 ABERTHAW CONSTRUCTION COMPANY, BOSTON Page 1

at Northwood Mass. PAY ROLL From 6/26/1913 to 7/2/1913

Man's No.	26	27	28	29	30	1	2	Total Hours	Rate	Amount
Lyell	9	9	9		9	9	9	54	37.00	37.00
Barker	11	9	9		10	9½	9	57½	18.00	18.00
Dunham	11	9	9		10	10	9	58	13.00	13.00
Rutledge	9	9	9		10	10	9	56	36.00	36.00
Sliders	9	9	9		9	10	9	55	25.00	25.00
611	9	9	9		10	10	9	56	30	16.80
614	9½	9	9		10	10	9	56½	50	28.25
615	5							5	30	1.50
616	9	9	9		8	10	9	54	45	24.30
617	9	9	9		10	10	9	56	50	28.00
618	9	9	9		10	10	9	56	"	28.00
619	9	9	9		10	11½	9	58	45	26.10
620	9	9	9		9½	11½	9	57	"	25.65
621	9	9	9		10	10	9	56	"	25.20
622	9	9	9		10	10	9	56	"	25.20
623	10	9	9		10	10	9	57	.25	14.25
639	11	9	5		10	9	9	53	30	15.90
640	11½	9	9½		10	10	9	60	25	15.00

Sheet made out by C. W. Dunham Approved T. R. Lyell Supt. Total $

Checked by W. L. Barker Approved Inspector

FIG. 223.—The pay roll (continued in Fig. 224).

it in to the timekeeper to enter in the column provided. It is often a difficult matter to insure correct reports being received on the quantities of work done, and at the time the system was installed the writer made a practice of visiting jobs monthly and making a rough survey of them whereby he could calculate from his original estimate the quantity of work done, and using

this as a check. The practice on our work has improved a good deal since then and it is very seldom necessary now to make this check, but it is one that should not be neglected by one starting on a cost accounting system, as without this check the cost accounts may be rendered worthless by quantities either in excess

Job No. 1990 — ABERTHAW CONSTRUCTION COMPANY, BOSTON — Page 2

at Northwood Mass — PAY ROLL — From 6/26/13 to 7/2/13

Man's No.	26	27	28	29	30	1	2	Total Hours	Rate	Amount
651	12½	9	9		10	9	9	64½	50	32 25
652	11½	1	9		9½	5½	9	45½	25	11 38
653	11	9	9		9	9	9	56		14 00
654	11	9	5		9½	9	9	52½		13.13
655	11	9	9		10	10	9	58		14 50
656	12	9	9	6	9½	9	9	63½	35	22.23
657	12½	9	9		9½	9	9	58	25	14.50
658	12½	9	9	6	9½	10	9	65		16 25
659	12	9	9		9½	9	9	57½	27½	15 81
660	12½	9	9		10	10	9	59½	45	26 78
662	12	9	9		4	6½	9	49½	25	12 38
663	11	9	9		10	10	9	58	30	17.40
664	11½	9	9		10	9	9	57½	25	14.38
665	12	9	9	6	9½	9	9	63½	35	22 23
666	6½							6½	25	1 63
667	11	9	9		9	9	9	56		14 00
668	11½	9	9		9	9	9	56½	"	14 13
670	11½	9	9		9½	10	9	58	25	14 50
671	11	9	9		10	10	9	58		14 50
672	11	9	9		9	10	9	57	"	14.25
673	8	8	8		8	8	8	48	62½	30 00
674	8	8	8		8	8	8	48	37½	18 00
675		8	8		8	8	8	40	62½	25.00
677	11½	9	9	6	9½	9	9	63	27½	17 33
679	11½	9	5		9½	10	9	54	25	13 50
681	11½	9	9		9	9	9	56½	30	16 95
682	11	9	9		9½	9	5	52½	25	13 13
683	11	9	9		10	10	9	58	"	14.50
684	2	9	9		5	2	9	36	"	9.00
685	11½	1	9		9	9	9	48½	"	12.13
686		9	9		10	5½		33½	"	8.38
690	11	9	9	6	9½	9½	9	63	25	15 75
691	12	9	9		10	10	9	59	"	14 75
692	11½	9	9		10	10	9	58½	25	14.63
693	11	9	9		10	10	9	58	30	17.40
697	11½	9½	8		10	10	9	58	20	11.60
										592.28
								Total first sheet		402 15
								Grand	Total	994 43

Sheet made out by C. W. Banks Approved J. R. Lyall Supt.

Checked by N. L. Parker Approved .... Inspector

FIG. 224.—The pay roll (continued from Fig. 223).

or less than the actual amounts being reported. On one job, some years back, we found that a superintendent had reported 20,000 sq. ft. more forms than he had put up, with a view to making his costs look low and getting credit for economical work. Our estimates show what the total quantities should be,

and an occasional survey and a final comparison will prevent any such errors being made now.

In concrete work the only item of labor that can be checked from the bills is the steel reinforcement, and every other quantity has to be obtained by scaling and computation. This is also true in most other branches of construction work, with the exception of structural steel.

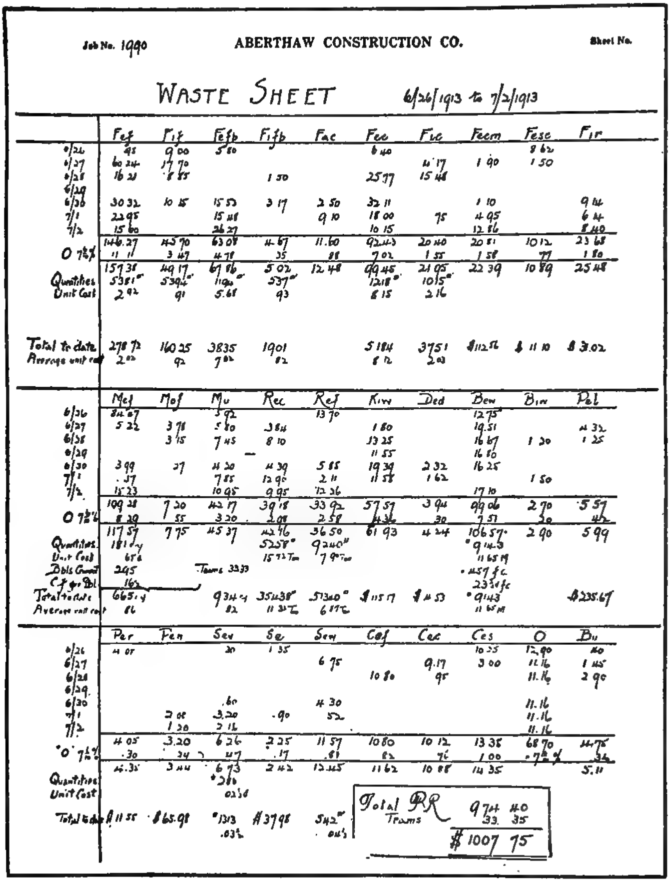
(*e*) *The Inquiry Form.*—We also use a brief standard form in case of any apparent mistakes on any of the reports received from the field. Often a man's rate is entered wrongly, or a different number of hours appears on the pay roll to that on the time sheet, or time is reported with no quantities or quantities with no time. It is only by picking up all these mistakes at once and having them corrected that a system is kept going properly, and the men in the field, knowing that their work is carefully watched, are more keen in getting work done accurately. This may seem to be a trivial detail, but the writer's experience is that it is not possible to get accurate and careful work from men in the field unless careful attention is paid to the smallest items, and any inaccuracies or omissions are promptly followed up. If the men on the job are made to realize that their works is important and really counts for something they will be a good deal more careful and eager to cooperate with the office in matters like this.

Section IV.—The Work in the Office—Labor Records

(*A*) *Working up the Time Sheets.*—As soon as the time sheets come into the office, the total cost of each operation is worked out and entered in the column headed "For Office Use" on the time sheets, as shown in Fig. 221. At the end of the week the totals are drawn off on to an abstract sheet, shown in Fig. 225, and the items are totaled. The overhead labor expense (superintendent, timekeeper, waterboy, etc.) is then distributed by adding a percentage to each item, and the complete cost of each operation for the week is determined. The quantities are then written underneath each one and the unit costs worked out. They are then entered on the office record sheets, which will be described in the next section, and under them is entered the total quantity of work done to date (which is obtained from the office sheet) and the average cost of the work to date.

(*B*) *The Weekly Summary.*—Figure 226 shows a copy of the weekly summary of labor costs. The top line shows the total

amount spent during the week on the items. The second line shows the quantity done, and the third line the unit cost. There are then left two or three lines for notes; in the case of concrete the number of barrels of cement used and the number of cubic feet of concrete obtained with a barrel of cement is noted. The



Job No. 1990 ABERTHAW CONSTRUCTION CO. Sheet No.

WASTE SHEET 6/26/1913 to 7/2/1913

	Fef	Fif	Fefb	Fifb	Fac	Fee	Fic	Feem	Fese	Fir
6/26	45	9 00	5 80			6 40			8 62	
6/27	60 24	17 70					4 17	1 90	1 50	
6/28	16 21	8 85		1 50		25 77	15 48			
6/29										
6/30	30 32	10 15	15 53	3 17	2 50	32 11		1 10		9 14
7/1	22 95		15 48		9 10	18 00	75	4 95		6 44
7/2	15 60		26 27			10 15		12 86		8 40
	146.27	45 70	63 08	4 67	11.60	92 43	20 40	20 81	10 12	23 68
O 7½%	11 11	3 47	4 78	35	88	7 02	1 55	1 58	77	1 80
	157 38	49 17	67 86	5 02	12 48	99 45	21 95	22 39	10 89	25 48
Quantities	5381"	5394"	1190"	537"		1218"	1015"			
Unit Cost	2 92	91	5.68	93		8 15	2 16			
Total to date	278 72	160 25	3835	1901		5184	3751	$112 56	$11 10	$3.02
Average unit cost	2 02	92	7 02	82		8 12	2 03			

	Mef	Mof	Mu	Rec	Ref	Kiw	Ded	Bew	Biw	Pel
6/26	84 07		3 92		13 70			12 75		
6/27	5 22	3 78	5 80	3 84		1 80		19.51		4 32
6/28		3 15	7 45	8 10		13 25		16 67	1 20	1 25
6/29						11 55		16 80		
6/30	3 99	27	4 20	4 39	5 85	19 39	2 32	16 25		
7/1	.37		7 85	12 90	2 11	11 58	1 62		1 50	
7/2	15 23		10 95	9 95	12 26			17 10		
	109 28	7 20	42 17	39 18	33 92	57 57	3 94	99 06	2 70	5 57
O 7½%	8 29	55	3 20	2 98	2 58	4 36	30	7 51	20	42
	117 57	7 75	45 37	42 16	36 50	61 93	4 24	106 57	2 90	5 99
Quantities	181 cy			5258"	9240"			9143		
Unit Cost	65			15 72 Ton	7 90 Ton			11 65 M		
Bbls Cement	245	Teams 33 33						457 fc		
Cf per Bbl	165							23 fc		
Total to date	665.14		934.4	35438"	51340"	$115 17	$4 53	9143		$235.67
Average unit cost	86		82	11 34 T	6 17 T			11 65 M		

	Per	Fen	Sev	Se	Sew	Cof	Cec	Ces	O	Bu
6/26	4 07		20	1 35				10 25	12 90	40
6/27					6 75		9.17	3 00	11.16	1 45
6/28						10 80	95		11.16	2 90
6/29										
6/30			.60		4 30				11.16	
7/1		2 08	3.20	.90	52				11.16	
7/2		1 20	2 16						11.16	
	4 05	3.20	6 26	2 25	11 57	10 80	10 12	13 35	68 70	4 75
"O" 7½%	.30	24	47	.17	.88	82	76	1 00	7½%	36
	4.35	3 44	6 73	2 42	12 45	11 62	10 88	14 35		5.11
Quantities			280							
Unit Cost			02¾							
Total to date	$11 55	$65.98	1313	$37 98	542"					
			.03½		.04½					

Total RR	974	40
Teams	33	35
	$1007	75

FIG. 225.—Waste sheet—quantities and unit costs.

two lower lines show the total quantity of that kind of work done to date and the average cost. Four copies of this sheet are made every week, and are furnished to the heads of the firm and the general superintendent, and one copy goes to the superintendent in the field. He also has a copy of the analysis. With these

two he is able for himself to see how the costs of his work are running and how they compare with the estimate. Most of our superintendents also work out daily unit costs in the field on the larger items of the work, to keep more closely in touch with their costs. We believe in letting our men know just what we expect of them in the way of costs, of letting them know just how they are coming up to or bettering our expectations. Since we adopted the plan of letting them know what the weekly costs were there has been a marked improvement in the unit costs and a real enthusiasm for getting low costs.

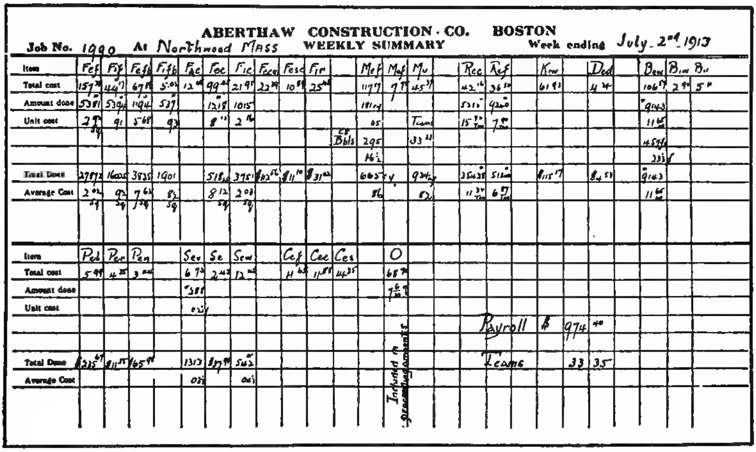
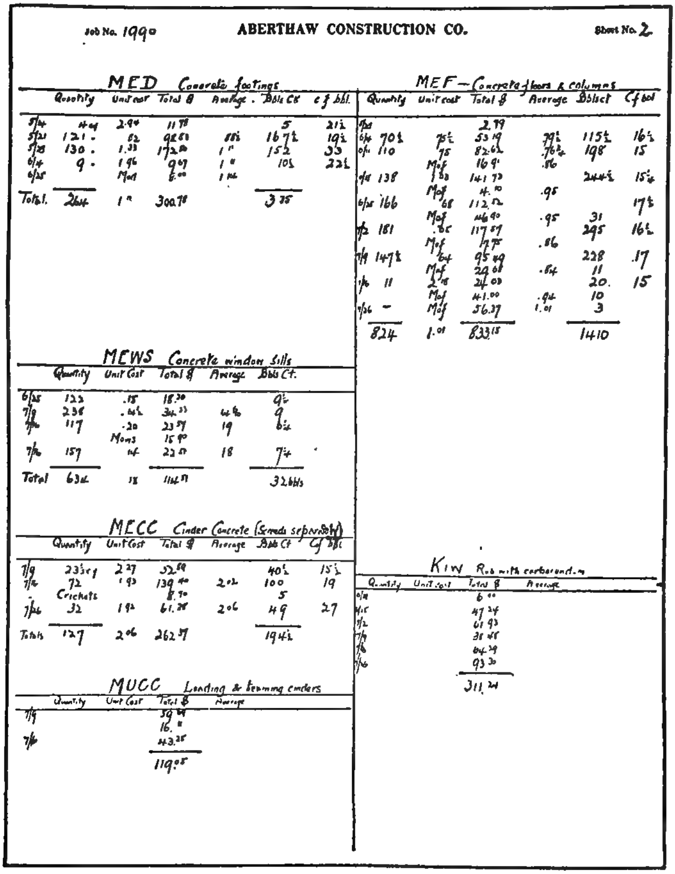

ABERTHAW CONSTRUCTION · CO. BOSTON
Job No. 1990 At Northwood Mass WEEKLY SUMMARY Week ending July 2nd 1913
Item / Total cost / Amount done / Unit cost / Total Done / Average Cost
Item / Total cost / Amount done / Unit cost / Total Done / Average Cost
Payroll $ 974.40
Teams 33.35

FIG. 226.—Weekly summary.

I may be asked why we do not "go one better" and work out daily costs in the office instead of weekly.—The reason this is not done is not on the ground of expense although it would be a very expensive proceeding—but because if we worked out the cost of every item each day we should have such an overwhelming mass of figures to study that we should never have any clear idea as to how the job stood; and then, again, the costs would show such astonishing variations from day to day that in many cases they would be useless. For example, suppose a line of sheet piling set up and braced one night, but not driven right down until the next day, following our rule (to report quantity when work is done) one day would show a large expense in money and no quantity, the next a large quantity with small expense and exceedingly low unit cost.

(*C*) *The Office Labor Sheets.*—Figure 227 shows the regular record of the labor which is kept in the office. This sheet shows only a few items and there should be about ten or twelve sheets for every job. It will be seen that the first column contains the date, the next the quantity of work done during the week, the



Job No. 1990 ABERTHAW CONSTRUCTION CO. Sheet No. 2

MED Concrete footings

	Quantity	Unit cost	Total $	Average	Bbls Ct	c f bbl.
5/14	4 cy	2.94	11 78		5	21½
5/21	121.	82	98 80	88½	167½	19½
5/28	130.	1.33	172 80	1 "	152	33
6/4	9.	1 96	9 07	1 "	105	22½
6/25		Mort	8.00	1 14		
Total.	264	1 "	300 78		3 75	

MEF—Concrete floors & columns

	Quantity	Unit cost	Total $	Average	Bbls ct	Cf bbl
5/28			2.79			
6/4	70½	75½	53 19	79½	115½	16½
6/11	110	75	82.62	.76¼	198	15
		Mof	16 91	.86		
6/18	138	1 03	141 73		244½	15¼
		Mof	4. 10	.95		
6/25	166	68	112.52			17½
		Mof	46 90	.95	31	
7/2	181	.65	117 57		295	16½
		Mof	17 75	.86		
7/9	147½	64	95 49		228	.17
		Mof	24 01	.84	11	
7/16	11	2 18	24 03		20.	15
		Mof	41.00	.94	10	
7/26	—	Mof	56.37	1.01	3	
	824	1.01	833 15		1410	

MEWS Concrete window Sills

	Quantity	Unit Cost	Total $	Average	Bbls Ct.
6/25	122	.15	18.30		9½
7/9	238	.14½	34 33	14%	9
7/16	117	.20	23 37	19	6½
		Mons	15 90		
7/26	157	14	22 81	18	7¼
Total	634	18	114 71		32 bbls

MECC Cinder Concrete (Screeds separately)

	Quantity	Unit Cost	Total $	Average	Bbls Ct	Cf bbl
7/9	23⅓ cy	2 27	52 89		40½	15½
7/16	72	1 93	139 40	2 02	100	19
-	Crickets		8.90		5	
7/26	32	1 92	61.38	2 06	49	27
Totals	127	2 06	262 57		194½	

MUCC Loading & teaming cinders

	Quantity	Unit Cost	Total $	Average
7/9			59 80	
			16. "	
7/16			43.25	
			119.05	

KIW Rub with carborundum

	Quantity	Unit cost	Total $	Average
6/18			6 00	
6/25			47 24	
7/2			61 93	
7/9			38 48	
7/16			64 29	
7/26			93 30	
			311 24	

FIG. 227.—Office labor sheet.

next the unit cost of that work, and the next column the total cost of that work. The next column contains the average cost of the work to date, combining the week's work with all the previous weeks. In the case of concrete, two additional columns are used, giving cement used and the proportion of the

mix. These are entered up from week to week from the abstract mentioned previously. The totals are kept in pencil at the foot of the columns and altered from week to week, so that it is a simple matter to add one week's work to the total of the preceding week and work out the average unit cost.

On some items, such as forms, the cost of making, erecting and stripping of forms is carried in separate columns, and another column is kept for the total unit cost of the work to date. This is obtained by adding the totals of the three money columns and dividing by the number of square feet erected. This inclusive unit cost does not give quite such an accurate idea of the cost as the three subdivisions do, as all the making is done at the beginning of the job and some of the stripping may not come until a good while after, but is in many cases a very useful figure to have, and it is, of course, the figure which compares with the analysis which is made out at the beginning of the job. As already mentioned, when the cost of the item for the week has been entered, the average is worked out and then the resulting average and the total quantity to date is transferred back to the waste sheet from which the weekly summary is made out.

Section V.—In the Office—The Material Records

Figures 228 and 229 show a part of the material records kept in the head office. These are entirely distinct from the bookkeepers' records and are not a ledger account. No merchants' names appear as a rule, but chiefly quantities of materials and costs.

The records are kept on loose sheets and at the start of the job columns are headed for each item that appears in the analysis. In some cases these items are subdivided. Then every item of expense is entered under its proper heading regularly as the work goes on. Freight in every case is entered with the item to which it relates. Demurrage also is entered in the columns of "Cement," "Brick," "Lumber," etc., as the case may be. The column headed "Cement" will also contain items of freight, freight on empty bags, credit on empty bags, tests, demurrage, etc., so that the final price per barrel of cement that appears in the final summary may be several cents higher than the price entered on the original order, especially if many empty bags have been lost. There is no column for all lumber. Lumber is entered under "Plant," "Forms," "Roof Plank," "Coffer-

dams," "Temporary Buildings," etc., according to the use it is to be put to. If lumber is bought for sheeting trenches and afterwards used for forms, it is first entered to the excavation item and then its second-hand value is credited and charged to forms. Credits are entered in red and in the same columns as

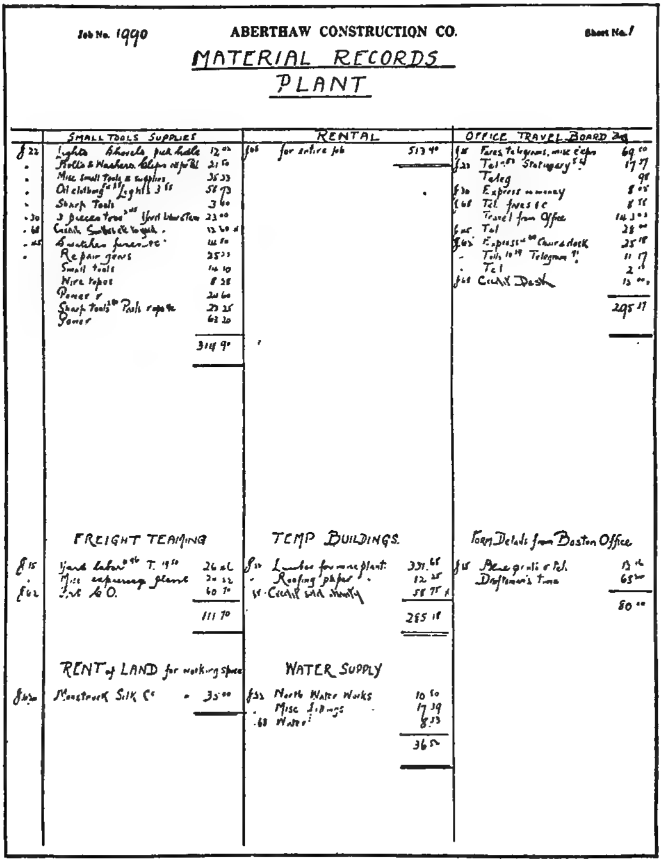


FIG. 228.—Material records (continued in Fig. 229).

debits, as there are very few of them and it would be cumbersome to have to keep double columns for each item to provide for possible credits.

To get hold of the information entered in these sheets the procedure is as follows: All bills are sent to the job to be checked and returned to the head office, from whence they are paid. As

soon as the receipted bills come in they are sent to the cost accounting department. They are then entered up in a waste book and at once returned to the bookkeepers. One waste book only is kept, and the bills are entered as they come in, a page at a time being kept for each job number, and another page

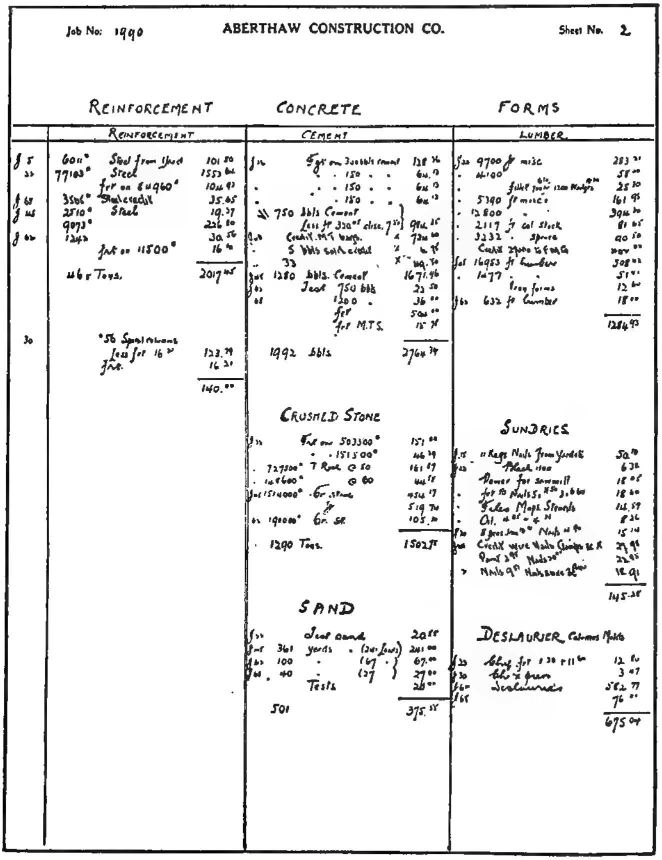


FIG. 229.—Material records (continued from Fig. 228).

taken when one is filled. When the bills are checked at the job, the material clerk notes on same what the material was used for (as in the case of lumber just referred to). This information is usually put in by using the timekeeper's code and then there is no question in the cost accounting department as to where to charge any unusual item. The use of the waste book is simply

to save time. The weekly labor summaries take precedence in the cost accounting room, and on the last three days of the week we are much too busy getting these out to give any time to the material sheets. These can be entered up later in spare moments. Once a month, at least, each job is brought up to date and the total compared with the bookkeeper's ledger.

All orders are also examined by the cost accounting department, and a note sheet kept on each job of all large orders and sub contracts, so that when a monthly statement is made of the financial standing of the job these can be included. The saving or loss on the estimate when a contract such as painting is sublet is not made when the final payment has been made, but when the order is given, and should be taken into account then. We do not, however, keep a record of any but the big orders, as the thousand and one small items of nails, bolts, tools, etc., are billed and paid for very soon after receipt and quickly find their place in our records from the bills.

Section VI.—The Monthly Statement.

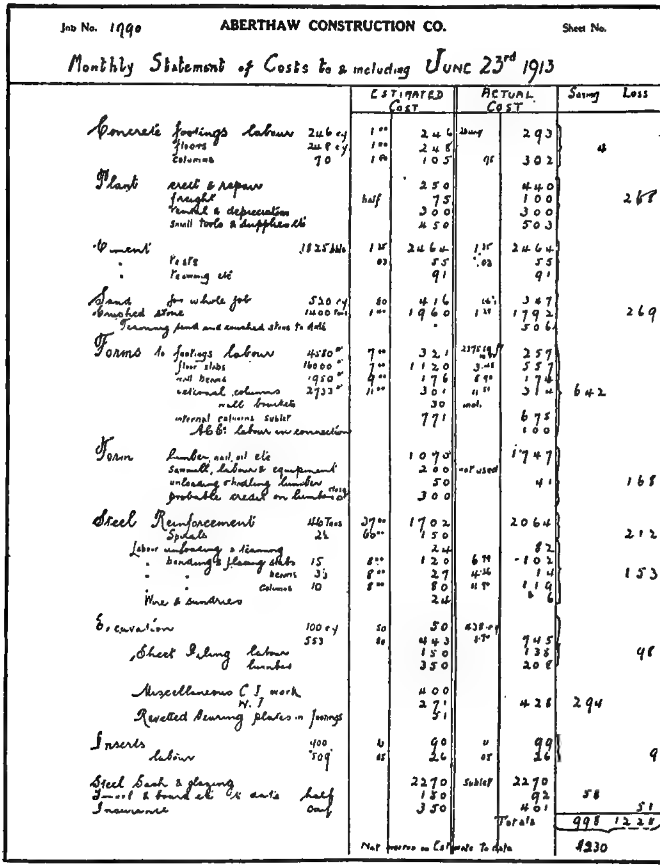
Figure 230 shows the statement which is prepared monthly to ascertain the amount money saved or dropped on the job. These are not made for every job on the same day, but by taking two or three jobs in turn each week we make it part of our regular routine without undue pressure at any time.

The weekly summaries showed labor costs only. If any item (excavating, for instance) was costing 20 cts. per yard more than the estimate, it did not show how many dollars the total loss amounted to. Every job fluctuates from week to week. Some items are over the estimate and some show a saving. This statement brings these items all into view in such a way as to show how serious an over-run may be, and the final footings show within a very small amount just how the job stands.

The way the sheet is made up is—first to copy from the analysis the description of all the items and place the unit prices in the column provided on the left. Then from the labor and material records to enter in the "Actual Cost" columns quantities of work done and materials purchased, with their unit costs and total costs to date. Then to work out in the "Estimated Cost" column the cost of the quantities done at the estimated prices. Then to enter all sub-contracts made in the "Actual Cost"

column and the corresponding "Estimated Cost," and finally to work out the totals saved or lost on each group of items.

A glance at the sheet (see Fig. 230) will show some considerable variations from the original estimate. It is not within the scope of this paper to discuss the actual costs on this work, but it will



Job No. 1990 ABERTHAW CONSTRUCTION CO. Sheet No.

Monthly Statement of Costs to & including June 23rd 1913

		Estimated Cost		Actual Cost		Saving	Loss
Concrete footings labour	246 cy	1.00	246	[illegible]	293		
floors	248 cy	1.00	248			4	
columns	70	1.50	105	95	302		
Plant erect & repair			250		440		
freight		half	75		100		268
rental & depreciation			300		300		
Small tools & supplies etc			450		503		
Cement	1825 bbls	1.35	2464	1.35	2464		
tests		.03	55	.03	55		
teaming etc			91		91		
Sand for whole job	520 cy	.80	416	[illegible]	347		
Crushed stone	1400 tons	1.40	1960	1.28	1792		269
Teaming sand and crushed stone to date					506		
Forms to footings labour	4580'	7.00	321	2375 sq ft	257		
floor slabs	16000'	7.00	1120	3.48	557		
wall beams	1950'	9.00	176	8.90	174		
external columns	2733'	11.00	301	11.50	314	642	
wall brackets			30	mat.			
internal columns sublet			771		675		
Add: labour in connection					100		
Form lumber, nail, oil etc			1070		1747		
Sawmill, labour & equipment			200	not used			
unloading & hauling lumber			50		41		168
probable credit on lumber at close			300				
Steel Reinforcement	46 Tons	37.00	1702		2064		
Spirals	2½	60.00	150				212
Labor unloading & teaming			24		82		
" bending & placing slabs	15	8.00	120	6.79	102		
" " beams	3½	8.00	27	4.26	14		153
" " columns	10	8.00	80	11.90	119		
Wire & sundries			24		6		
Excavation	100 cy	.50	50	438 cy			
	553	.80	443	1.70	745		
Sheet Piling labour			150		138		98
lumber			350		208		
Miscellaneous C.I. work			400				
W.I.			271		428	294	
Riveted bearing plates in footings			51				
Inserts	400	[illegible]	90	[illegible]	99		
labour	509	.05	26	.05	26		9
Steel Sash & glazing			2270	Sublet	2270		
Travel & board etc. ½ cents	half		150		92	58	
Insurance	only		350		401		51
				Totals		998	1228
Net [illegible] on Estimate to date						$230	

FIG. 230.—Monthly statement.

be well to point out what is shown on the sheet and to give a few explanations as to local conditions to make things clear.

It will be seen, first, that concrete labor is running very close to the estimate, although the quantity placed in the footings was 18 yd. in excess of that estimated. Plant shows a loss of $268,

chiefly on the labor items. An old construction elevator was sent to the job, which was rather out of repair and several parts had to be refitted or remade before it could be erected. There is also a loss on the sand and stone. It was found that the crusher which had been counted on to supply us could not be depended on, and we therefore had to purchase from a quarry further away, which had a railroad delivery, and to unload and team from the railroad, which was about a mile away. As we were thus using teams regularly we decided to buy f. o. b. teams at the pit, instead of f. o. b. at the job, so as to keep teams steadily employed, so the statement shows a saving on sand and stone offset by an overrun on teaming. It is not necessary at this time to discuss the other variations, but simply to note that the difference between the savings and the losses shows a net loss of $230 on the estimated total.

The amount of contractor's profit does not appear on these sheets or in any of the cost accounting records, and the amounts of savings or loss in the monthly statements have to be added to or deducted from the estimated profit.

Section VII.—Monthly Comparison of Best Performances

Table 15 shows a statement which we prepare monthly showing the unit labor costs of the three or four principal items of construction on all jobs during the preceding month. A copy of this sheet is sent to every one of our foremen and superintendents. This is not an essential part of our system, but it is awaited with great interest by our field superintendents and has proved a very useful factor in stimulating a general interest in the timekeeping and cost accounting work, and is an additional incentive to our men to try for low costs.

The costs shown on this statement are nearly always lower than our average costs, as they show the best work done month by month and do not bear any preliminary expense or other incidental items. They will give some idea of what *can* be done under favorable circumstances, but would not be a safe guide for estimating future work.

Section VIII.—The Final Comparison

Figures 231 and 232 show the final comparison of estimated with actual costs. This is similar to the monthly statement

Table 15.—Copy of Sample Sheet Showing Monthly Comparison of Best Performances

Principal Unit Costs for Month of October, 1911

	Job No.	Cubic yards	Unit cost
Concrete—Unload, mix and place:			
N.B. 2 mixers on Job 941			
Largest 6 days' run of concrete	917	313	$0.71
	941	2,205	0.38½
	944	602	0.62½
	946	558	0.57
Largest 1 day run of concrete	917	107½	0.80½
	941	451	0.38
	944	150	0.54½
	946	233	0.51½
Lowest day's unit cost—floors	917	96	0.68½
	941	408	0.31⅛
	944	16½	0.31½
	946	132	0.38
Month's average unit cost	917	700	1.17
	941	5,030	0.59½
	944	1,418	1.02
	946	393	0.84
		Square feet	Per 100 sq. ft.
Forms—Erecting only:			
Floor forms	917	45,628	$3.53
	941	291,016	3.92
	944	82,107	6.24
	946	24,568	7.10
Wall forms	917	None	None
	941	31,556	5.80
	944	3,855	9.59
	946	15,247	7.47
Column forms	917	3,725	3.17
	941	41,260	7.15
	944	11,494	9.08
	946	7,095	10.05
		Tons	Per ton
Placing floor steel (beam and slab)	917	82.18	$5.36
	941	886.50	4.17
	944	63.82	6.47
	946	37.00	6.85
Bend and place column steel	917	6.56	5.30
	941	14.33	2.84
	944	15.92	8.62
	946	7.33	14.71

(Section VI) and needs no further explanation as to the method adopted, but a brief notice of some of its chief features will be of interest.

The cost of laying wood screeds to receive the top flooring was unexpectedly high. The bulk of it was done in one week

Job No. 1990 ABERTHAW CONSTRUCTION CO. Sheet No. 1

Final Statement of Costs.

	Quantities Estimated	Quantities Reported	Estimated Cost		Actual Cost		Saving	Loss
Concrete Labour on footings	246 cy	264 cy	1.00	246	1.14	301		
" " columns	169 "	169	1.50	254	1.01	171		
" " floors	690 "	655	1.00	690	1.01	662	37	
" " window sills	629 ft	634 ft	15	95	18	114		
" cinder concrete crickets				20				
" cinder concrete fill					2.06	262		
& laying screeds	125 cy	127	2.00	250	Screeds	326		338
Rub with carborundum				300		311		11
Plant Labour erect & dismantle				300		801		
" freight etc				150		112		
" rental				300		514		864
" Small tools & supplies				450		637		
Cement	2000 bbl	1972 bbl	1.35	2700	1.36	2682		
" tests			.03	60	03	54		
" unloading teaming &c				100.		92		
Sand	520 cy	501	.80	416	.75½	376		106
Crushed Stone	1400 tons	1290 tons	1.40	1960	1.16	1502		
Teaming sand & stone						546		
Cinders	130 cy		[illegible]	65	[illegible]	202		
Concrete sundries				52				
Forms to footings labour	Sq ft 4580	2375	7.00	321	10.80	257		
" " floor slabs	28618	27872	7.00	2005	3.58	997		
" " wall beams	3918	4025	9.00	359	9.34	376		
" " external columns	7300	6808	11.00	803	9.03	615		
" " wall brackets	55		70	39	Mill			
" " internal col. heads	Sub contract.			771	Sublet ACC	675 / 115	944	
" " window sills	629 ft.	631	15	94	16	101		
Form lumber, nails, oil etc				1070		1430		
Unloading, handling lbr, cleaning &c				50		221		
Sawmill				200	Not used			
Detailing forms in Boston Office				100		81		
Steel Reinforcement	46 T	46½ T	37.00	1702	av. 43.44	2019		
" " spirals	2½ T	2½ T	60.00	150	56.00	140		
" " tests				10				
" " unloading	48½ T		50	24				311
" " wire & sundries				24		7		
" " bend & place in floors		26½ T	8.00		8.14	216		
" " " " columns	48½ T	17 T	8.00	388	11.32	193		
" " " " sundries		5½ T	8.00		7.00	36		
Inserts	1000	1313	.10	100	09½	125		
" labour	1000	1313	.05	50	.03½	46	23	
" billed as extra	313		15	47				
Carried forward							1004	1630

FIG. 231.—Final statement of costs (continued in Fig. 232).

at the close of the job when the best men had been transferred elsewhere, and is a good illustration of necessity of unceasing vigilance in superintendence to avoid sudden drops like this. The rest of the carpenter work was very well done, showing a saving of $944 on the forms. Plant continued to run high;

110 tons less of stone was used then estimated, owing to its being extremely well graded and therefore economical in use. Cinders cost three times the estimated amount, owing to there being none available at the owner's plant and no other factories near

Job No. 1990 **ABERTHAW CONSTRUCTION CO.** Sheet No. 2

	Quantities	Estimated Cost		Actual Cost		Saving	Loss
Brot. forward						1004	1630
Brickwork labour	1200 c.f	.20	240	.27½	332		
material	28 M		420	9.00	256	8	
				Lime	42		
				Cement 784	23		
Cutting & patching old work			50		49		
Metal lathed & plastered partition			54		37	17	
Repair old floors			250		172		
Pine Seats			160		145	125	
Wood Stairs			35		30		
Pipe Rail			.50				
Miscellaneous fast iron work, walls			400				
west			271		428	376	
Riveted bearing plates			51				
Labour on Misc ironwork			106		74		
Tinned doors			60	inc. frames	91		31
Steel Sash & glazing			2270		2270		
erection	5262 sq ft	.05	263	.05½	268		5
Excavation	100 c.y	Estd .50	50				
	553 c.y.	.80	442				
Reported	435 c.y			1.70	745		86
Grading			100		10		
Sheet Piling lumber			350		218		
labour			150		205		
Clean up the job, clean glass etc			100		124		24
Travel, board, superintendence etc			300		295	5	
Liability Insurance			400		450		50
Contingencies & sundries			400		55	345	
						1883	1826
		Net gain in Estimate.				$57	

FIG. 232.—Final statement of costs (continued from Fig. 231).

which could supply us. Some of the cinders had to be teamed 4 miles.

Section IX.—The Final Summary

When the job is completed and all accounts are paid, the figures are worked up into a final summary which shows the

costs in the same manner as the original estimate. The cost of plant, cement, etc., is added to labor cost of forms, and in general figures are compiled which correspond with the prevailing methods of figuring construction work.

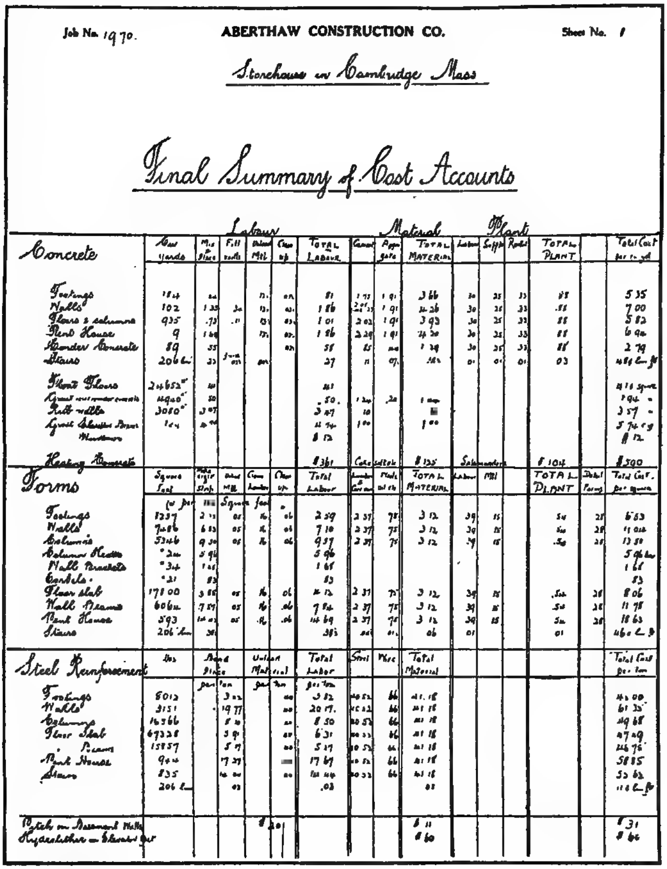


FIG. 233.—Final summary of cost accounts (continued in Fig. 234).

The final summary on the job from which my other exhibits have been taken is not yet made up, so I have taken one from another job, a storage building, completed last year (see Figs. 233 and 234). It shows the method of setting out the figures so that, at a glance, any of the important details of the cost can be referred to. The final summaries of all the jobs are bound

together in a loose-leaf book and are not filed with the job records. They are thus always at hand for ready reference when estimating future work.

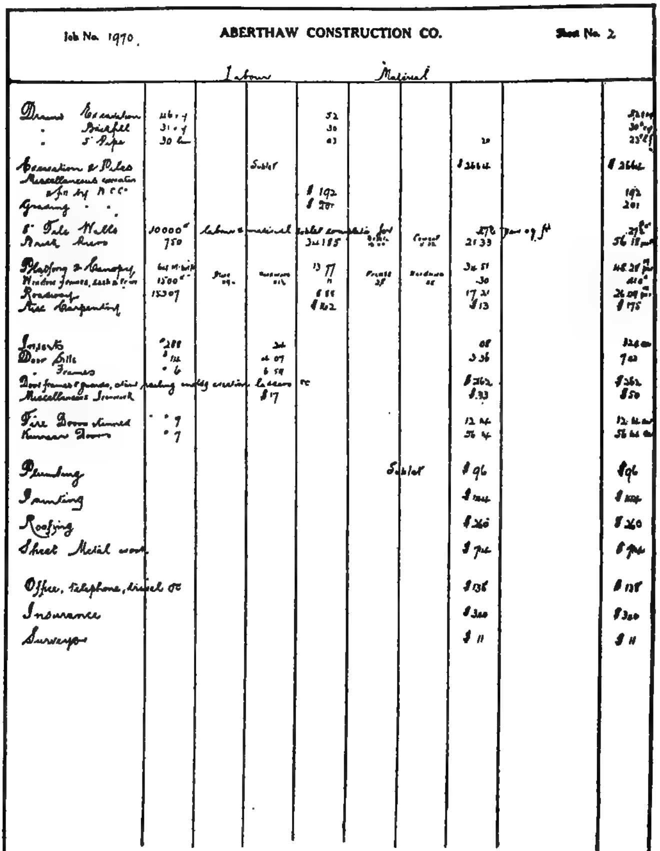


FIG. 234.—Final summary of cost accounts (continued from Fig. 233).

Conclusions

The system has been used by the Aberthaw Construction Co. for over 2 years, and it is interesting to look back and see what results can be traced to an accurate system of cost accounting. In comparing my estimates of 5 years ago with those made today, I find that I estimate concrete labor at least 40% lower than then. On the other hand, I have found that not half enough money used

to be figured for plant and tools. Our labor costs on forms have come down over 25%, but I think that most of the saving on this item is due to improved designs and methods of erection than to a study of the unit costs. Steel reinforcement is handled for probably 10% less than before. Our superintendents have all got a good knowledge of costs, and are really interested in following them from week to week. If a special and unusual piece of construction work is to be built, our men are keen to find out just what it costs.

Some time ago a large job began to show high unit costs; 6 weeks after the footings were complete the monthly statement showed that labor had overrun the estimate by $10,000. From any point of view but the cost accounting the job looked all right—well-organized, and a large force of men all working busily. Each week's report showed unit costs as high as it predecessor. At the expiration of the 6 weeks the organization of the job entirely changed; a new carpenter foreman was put on and several other alterations in the force were made, and at once costs began to go down. At the end of the whole job the whole of the $10,000 overrun had been picked up and a saving of about $700 made on the estimated labor costs. It is not often that such extensive changes are needed, but often on a job some item runs too high for 2 or 3 weeks. Special attention is given to that item until it is reduced to its normal level. I believe that our system is a reliable barometer, showing from week to week what our jobs are doing. The contractor does not want a postmortem which, however interesting, does not bring back lost profits. He wants to know as the job goes along whether he is making money or not, where his profits or losses are, and whether his losses can be stopped.

Our system is elastic enough to take care of any special situations or furnish any information required. A little time back, I wished to analyze closely the cost of our form work with a view to furnishing our chief engineer with data which would guide him in making the most economical form designs possible. It was a simple matter for me in laying out the code for three jobs to subdivide the form work symbols by adding fourth letters, and get the cost and quantities of posts, joists, mud sills, panels and beam sides, etc., all reported separately and their unit costs worked out, so that we were able to compile data showing how much each post, joist, etc., cost to erect.

Although the system may at first sight seem to be complicated and costly, it is not so in fact. The work in our office is all done by my two assistants, who work with adding machines, and I give not more than one-fifth of my own time to supervising and directing it. Our total pay rolls in the summer-time sometimes amount to as much as $18,000 a week, and this is all handled by these two men without difficulty, and leaves my chief assistant time to visit the jobs occasionally. In the field we spend little more than other contractors do on timekeeping. On a job having a pay roll of $1,500 to $2,000 a week, one timekeeper at $15 would give his whole time to timekeeping. All the materials would be looked after by a material clerk at about the same wage. Larger and smaller jobs would have different organizations as their needs required.

I think the difficulties which are hardest to overcome and which need the most careful attention are: first, getting the timekeepers interested enough to study their work and divide the time rightly; second, seeing that quantities are reported for every item and reported correctly; and, third, having the figures handled in the office by men that understand them. My assistants have been picked not from the ranks of bookkeepers but from our own timekeepers. I am sure all the time that they know the meaning of the figures they are handling and can detect errors as they occur.

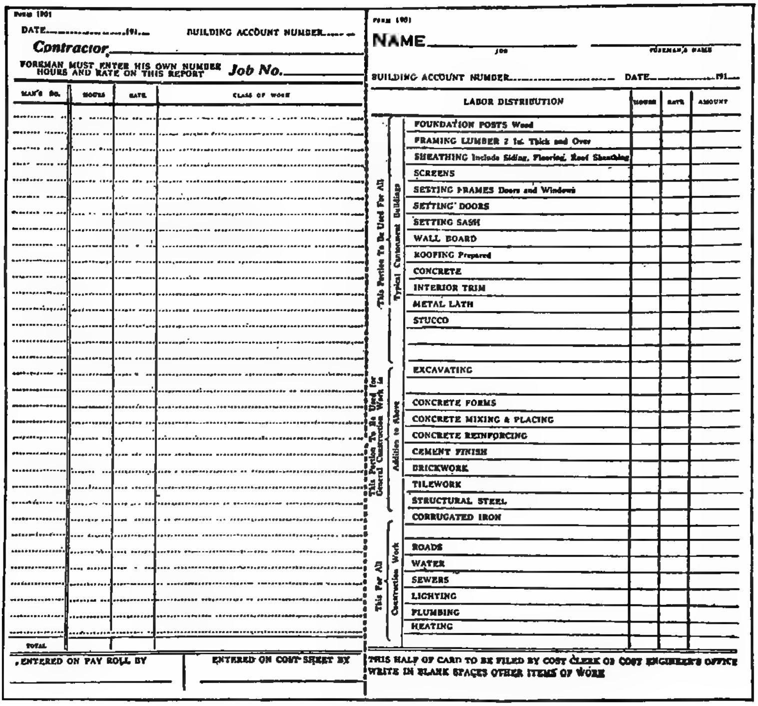
For the establishment and conduct of a proper cost accounting system on construction work, the chief requisites do not seem to be so much a high degree of technical skill and expert knowledge as much as a common-sense view of the problem to be tackled and patient persistence in working out the details, refusing to be halted by any obstacles. It is easy to pay large fees to experts to install a system. It is not so easy to plug away week after week working out the system, patiently instructing men, detecting errors, correcting them, overcoming opposition, and *getting results.*

The Cost Accounting System of Construction Division, U. S. Army.—Mr. C. W. Pinkerton, formerly cost engineer at Camp Beauregard, La., has written the following in *Engineering and Contracting*, May 21, 1919.

The basis of the cost accounting system used by the Construction Division of the United States Army during the recent period of rapid building of cantonments, depots, hos-

pitals, terminals, etc., is the foreman's daily report blank, Fig. 235. The foreman fills out only the left half of the card, which is used for all labor and team service.

When this report reaches the office it goes first to the pay-roll clerk, who makes his entries therefrom preparatory to making up the pay roll. The report then goes to the cost department. After it has been passed by the pay-roll clerk to



Form 1901

DATE .... 191.. BUILDING ACCOUNT NUMBER ....

Contractor, ____________

FOREMAN MUST ENTER HIS OWN NUMBER HOURS AND RATE ON THIS REPORT *Job No.* ________

MAN'S No.	HOURS	RATE	CLASS OF WORK
TOTAL			

ENTERED ON PAY ROLL BY ________ ENTERED ON COST SHEET BY ________

Form 1901

NAME ________ (JOB) ________ (FOREMAN'S NAME)

BUILDING ACCOUNT NUMBER .... DATE .... 191..

		LABOR DISTRIBUTION	HOURS	RATE	AMOUNT
This Portion To Be Used For All	Typical Cantonment Buildings	FOUNDATION POSTS Wood			
		FRAMING LUMBER 2 In. Thick and Over			
		SHEATHING Include Siding, Flooring, Roof Sheathing			
		SCREENS			
		SETTING FRAMES Doors and Windows			
		SETTING DOORS			
		SETTING SASH			
		WALL BOARD			
		ROOFING Prepared			
		CONCRETE			
		INTERIOR TRIM			
		METAL LATH			
		STUCCO			
This Portion To Be Used for General Construction Work in	Addition to Above	EXCAVATING			
		CONCRETE FORMS			
		CONCRETE MIXING & PLACING			
		CONCRETE REINFORCING			
		CEMENT FINISH			
		BRICKWORK			
		TILEWORK			
		STRUCTURAL STEEL			
		CORRUGATED IRON			
This For All	Construction Work	ROADS			
		WATER			
		SEWERS			
		LIGHTING			
		PLUMBING			
		HEATING			

THIS HALF OF CARD TO BE FILED BY COST CLERK OR COST ENGINEER'S OFFICE
WRITE IN BLANK SPACES OTHER ITEMS OF WORK

FIG. 235.—The foreman's daily report blank.

the cost department, no change can be made on the pay roll without having a corresponding change on the foreman's report involved.

The cost department examines the report to see that all needed information is given thereon. Reports having insufficient details are sent back to the foremen for correction.

From the details furnished by the foremen, the cost clerks make the extensions on the right half of the card and carry the totals to their own books. The form of these books is left to

the Cost Engineer on each job to design for himself, and as the writer has seen none which he does not consider too cumbersome none is reproduced herewith. A simple recapitulation sheet in a loose leaf binder will serve the purpose.

Only one job can be reported on one card and each foreman is required to fill out as many cards as the number of jobs on which he works during the day.

At the same time the building inspector turns in daily the form reproduced as Fig. 236, showing the percentage of work done on various items in the buildings under his charge. The card provides places in which he may check progress under

Form 1900 THIS CARD TO BE USED FOR ALL TYPICAL CANTONMENT BUILDINGS
USE A SEPARATE CARD FOR EACH KIND OF BUILDING DATE..............................191...

NAME ________________ ________________ ________________
JOB KIND OF BUILDING ESTIMATOR'S NAME

QUANTITY ESTIMATE REPORT ON BUILDINGS NUMBERS ________________

LABOR DISTRIBUTION	BLD'G NO.				BLD'G NO.				BLD'G NO.				BLD'G NO.				BLD'G NO.				BLD'G NO.				BLD'G NO.				BLD'G NO.				BLD'G NO.				BLD'G NO.			
	1/4	1/2	3/4	4/4	1/4	1/2	3/4	4/4	1/4	1/2	3/4	4/4	1/4	1/2	3/4	4/4	1/4	1/2	3/4	4/4	1/4	1/2	3/4	4/4	1/4	1/2	3/4	4/4	1/4	1/2	3/4	4/4	1/4	1/2	3/4	4/4	1/4	1/2	3/4	4/4
FOUNDATION POSTS Wood																																								
FRAMING LUMBER 2 In. Thick and Over																																								
SHEATHING Include Siding, Flooring, Roof Sheath																																								
SCREENS																																								
SETTING FRAME Doors and Windows																																								
SETTING DOORS																																								
SETTING SASH																																								
WALL BOARD																																								
ROOFING Prepared																																								
CONCRETE																																								
INTERIOR TRIM																																								
METAL LATH																																								
STUCCO																																								
EXCAVATING																																								

THE BUILDINGS LISTED HERE ARE COMPLETED IN ALL ITEMS..............................

Fig. 236.—Form used by inspector for reporting on work done on various items in building under his charge. Actual size of form: $4\frac{1}{2}$ in. $\times$ $8\frac{1}{2}$ in.

columns headed $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, $\frac{4}{4}$; or instead of checking these he may give the percentage done in figures. Only one kind of building may be reported on one card.

Quantities are determined by the engineers on the job. The quantity of work accomplished or completed during the current week and the total to date may be obtained by two methods: (*a*) the determination of the total quantities to date and the subtraction therefrom of the quantities reported to date as of the close of the previous week; and (*b*) the determination of the quantities of work from the point or line of completion as of the close of the previous week and the addition thereto of the quantities previously reported. The first method is generally prefer-

able as it serves as a check against the reporting of excess quantities.

Upon the completion of a project the engineers prepare a report showing the special conditions of labor, weather and all particular difficulties encountered. In reporting labor unit costs, any which are particularly low or high are commented upon.

From the summaries of data obtained the foremen's reports together with the estimates and the progress reports of the building inspectors, the cost engineer prepares on the form shown as Fig. 237 his weekly report of labor unit costs.

FORM 1902 FOR CANTONMENT CONSTRUCTION

NAME ______________ ______________ ______________
JOB — KIND OF BUILDING — ESTIMATOR'S NAME

UNIT LABOR COST SHEET **THIS CARD MUST BE SENT TO WASHINGTON WEEKLY** DATE ....191...

LABOR DISTRIBUTION	NUMBER OF BUILDINGS COMPLETED	TOTAL QUANTITY COMPLETED TO DATE	TOTAL QUANTITY LAST REPORT	NET QUANTITY CURRENT WEEK	TOTAL LABOR COST CURRENT WEEK	TOTAL LABOR COST TO DATE	UNIT LABOR COST CURRENT WEEK	AVERAGE UNIT LABOR COST TO DATE
FOUNDATION POSTS Wood								
FRAMING LUMBER 2 In. Thick and Over								
SHEATHING Include Siding, Flooring, Roof Sheath								
SCREENS								
SETTING FRAMES Doors and Windows								
SETTING DOORS								
SETTING SASH								
WALL BOARD								
ROOFING Prepared								
CONCRETE								
INTERIOR TRIM								
METAL LATH								
STUCCO								
EXCAVATING								

FIG. 237.—Form for weekly report of cost engineer on labor unit costs. Actual size of form: 4½ in. × 8½ in.

The forms (Figs. 236 and 237) are used for all typical cantonment buildings. Two similar forms are used for general construction work in addition to the above and are provided with the classification shown in the center of the right half of the former (Fig. 235). These last cards are used only where large quantities of the work described by the classifications thereon are involved.

An effort was made to adopt a system which would not put a burden on the field forces and which would not require great expense for an organization. It was felt that on each project the field forces should consist of a cost engineer, a quantity

estimator, and a cost clerk. The duties of the cost engineer were to:

(*a*) Have general oversight of the field and of the unit labor cost program,
(*b*) Instruct the foreman in the filling out of form 1901,
(*c*) Analyze the unit labor costs,
(*d*) Determine the causes for excessive costs, and
(*e*) Recommend to the Construction Quartermaster the remedy therefor.

In addition to this, the cost engineer was given a certain authority over timekeepers, material checkers, invoice clerks and purchasing department employes to see that the data needed by him were promptly and accurately furnished. He was allowed to use the timekeepers and time checkers for the purpose of returning for correction any reports on which an insufficient or questionable description of work appears.

The classification of buildings worked out by the Cost Accounting Division for comparison of costs of buildings of the same type is being adopted by a number of contractors who have seen it, with, of course, such changes as bring it within the needs of each contractor. This classification consists of a series of primary numbers and another series of secondary numbers.

The primary classification, series 200 and upwards, is used to show the item of construction on which it is desired to keep costs. Each primary account number represents the same item of work or subdivision of the project, wherever used, regardless of appropriation, location, or contract.

The second classification, series 1 to 150 inclusive, is used to show the various kinds of work done under the items of the primary classification. Each secondary account number represents the same kind or character of work regardless of other details.

The primary classification must always be used in connection with the secondary classification. For example, if the building being constructed carries the primary classification account No. 201 and it is desired to charge plumbing (secondary classification No. 18) against that building, the cost distribution would be 201–18.

The classification follows:

Type or Class of Construction

Primary Account Number	
201	66 men barracks, 30 by 60 ft.
202	Two-story buildings, 20 ft. wide.
203	Two-story buildings, 30 ft. wide.
204	Two-story buildings, 43 ft. wide.
206	Types G. & H. officers' quarters.
207	Lavatories.
208	Latrines.
209	Showers.
210	Post office.
211	Detention huts.
212	Assembly halls.
213	Storehouses, 60 ft. wide.
214	Two-story warehouse, 72 by 116 ft.
215	Magazines.
216	Shops, 36 ft. wide.
217	Blackwmiths shops.
218	Closed stables, 24 ft. wide.
219	Open stables, 24 ft. wide.
220	Open sheds, 29 ft. wide.
221	Hay sheds.
222	Watering troughs.
223	Feed troughs.
224	Hay racks.
225	Loading platforms.
226	Dipping tanks.
227	Fences and gates.
228	Flooring and framing for tents.
231	65 ft. wide garages.
232	Fire stations.
233	Grain storage elevator.
234	Motor and service station and repair shops.
235	Repair shops, 60 ft. wide.
236	Lecture halls, 120 by 167 ft.
237	Drill halls, 200 by 300 ft.
239	Coffee roasting plant.
246	Delousing plant.
401	Ice and cold storage plants.
402	Laundry buildings.
403	Bakery buildings.
404	Incinerators.
405	Reservation fences.
502	Library theater.
701	Hospital building (one story frame).
703	All two-story masonry and frame.

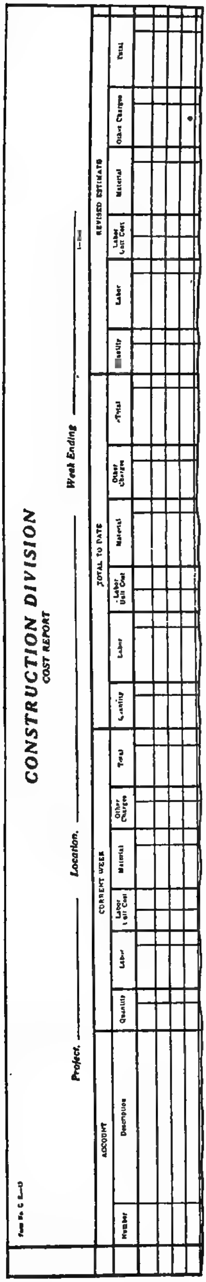
704 All other buildings.
705 Connecting corridors.
816 Well houses.
1035 Power house.
1506 Coal trestle.

Secondary Classification to cover details of construction used in connection with the Primary Classification.

Secondary
Account
Number

Details

3 Excavation and backfill.
7a Foundations, masonry, and
7b Foundations, steel (these accounts to be used only if building is very large or will house heavy machinery and equipment).
9 Concrete (can be used for concrete piers, floors, etc., or when large quantities of concrete are poured. State why account is used, *i.e.*, Concrete piers, and floors, concrete walls, etc.).
15 Carpentry.
a—Foundation posts (wood).
b—Framing and erecting lumber (2 in. thick and over).
c—Sheathing (including siding, flooring, roof sheath).
d—Setting frames for doors and windows.
e—Setting doors.
f—Setting sash.
g—Interior trim.
37 Screening.
53 Wallboard.
42 Roofing (state kind).
17 Painting.
18 Plumbing.
19 Ranges and kitchen equipment.
20 Heating, stoves.
23 Sheet metal work.
25 Elastic lighting, interior.
33 Tile (used for walls, partitions, etc.).
34 Structural steel (used only in large structural steel construction).
38 Permanent machinery or equipment.
a—Pumps and piping.
b—Engines.
d—Boiler house equipment.
f—Switchboard.
k—Miscellaneous equipment or machinery.
39 Fire protection.
a—Fire apparatus.
b—Sprinkler system.
c—Fire alarm system.


CONSTRUCTION DIVISION
COST REPORT

Project. ______ Location. ______ Week Ending ______

Account		Current Week						Total to Date						Revised Estimate					
Number	Description	Quantity	Labor	Labor Unit Cost	Material	Other Charges	Total	Quantity	Labor	Labor Unit Cost	Material	Other Charges	Total	Quantity	Labor	Labor Unit Cost	Material	Other Charges	Total

FIG. 238.—Form for weekly total cost report. Actual size of form: 15 in. × 21¾ in.

41 Miscellaneous iron work (does not include reinforcing for concrete).
65b Doors, steel or fire doors.
69 Foundations for machinery (cost to be collected under this account only when extra foundations are placed to accommodate machinery and should not be confused with 7a and 7b).
89a Tanks, steel (to be used for gasoline pump station).

The weekly total cost report is prepared on the form illustrated as Fig. 238. In this form, under column for accounts is typewritten the list of needed account numbers in accordance with the classification. Opposite the number the description of the work and the number of building with dimensions should be placed, as

"702—Two Story Frame Hospitals (6) —″x—″—″—″

Below this line the proper sub-heading or secondary numbers, as

3 Excavation.
15b Framing.
15c Sheathing.
15e Setting doors.
53 Wallboard.
18 Plumbing, etc.

Transfer the distribution of pay rolls under labor column, and materials and supplies under material and supplies column on the cost forms. The five totals as shown at end of cost accounting classification schedule as furnished by the cost department are self-explanatory.

A. Total direct cost is totals of form (Fig. 238).
B. Total indirect cost is totals of form (Fig. 239) transferred.

Form No. C. K.—14.

CONSTRUCTION DIVISION

OVERHEAD, PRORATE, AND INDIRECT CHARGES

Project.................... Location.................... Weeking Ending....................

Account Number	Account Description	Current Week Labor	Current Week Material	Current Week Other Charges	Current Week Total	Total to Date Labor	Total to Date Material	Total to Date Other Charges	Total to Date Total	Estimated Cost—Revised Estimate Labor	Estimated Cost—Revised Estimate Material	Estimated Cost—Revised Estimate Other Charges	Estimated Cost—Revised Estimate Total
	OVERHEAD, PRORATE, AND INDIRECT CHARGES												
151.	Unloading and loading plant and materials,												
151a.	Unloading and storing lumber,												
151b.	Unloading and storing cement,												
151c.	Unloading and storing rock,												
151d.	Unloading and storing gravel,												
151e.	Unloading and storing sand,												
151f.	Unloading and storing reinforcement,												
*152.	Operation of construction equipment.												
*153.	Repairs to construction equipment.												
154.	Purchase of construction equipment.												
*155.	Rental of construction equipment.												
156.	Tools and repairs to tools (includes operation of blacksmith and machine shops).												
157.	Temporary lighting and power.												
158.	Temporary water supply.												
159.	Temporary buildings.												
160.	Temporary roads.												
161.	Maintenance of existing roads outside reservation.												
162.	Temporary tracks.												
163.	Guards and watchmen.												
164.	Sanitation expenses.												
165.	Losses and expenses.												
166.	Cleaning up after completion of work.												
167.	Commissary operations—net profit or loss.												
168.	Water boys.												
169.	Miscellaneous Supplies (lubricants, waste, gasoline, fuel, etc.)												
171.	Premiums on bonds.												
172.	Premiums on liability and workmen's compensation insurance.												
174.	Contractor's fee.												
175.	Other indirect expenses (too small for separate account).												
	FIELD ORGANIZATION OF CONTRACTOR												
181.	Salaries.												
182.	Transportation and expenses.												
183.	Office furniture and fixtures.												
184.	Office supplies and expenses.												
185.	Purchase, operation, maintenance and rental of passenger autos.												
	FIELD ORGANIZATION OF CONSTRUCTING QUARTERMASTER												
188.	Salaries.												
189.	Transportation and expenses.												
190.	Office furniture and fixtures.												
191.	Office supplies and expenses.												
192.	Purchase, operation, maintenance and rental of passenger autos.												
194.	Transportation and expenses of contractor's force (excluding field organization).												
195.	Freight and express charges paid by contractor.												
*196.	Purchase, maintenance, operation and rental of vehicles other than passenger automobiles.												
*197.	Team service.												
	TOTAL												

*Costs which can not be directly charged against specific items of work.

FIG. 239.—Form for listing overhead, probate and indirect charges. Actual size of form 15 in. × 21¾ in.

C. Total cost is totals of direct and indirect cost.

D. Unpaid wages. This shall be deducted from labor and total columns.

E. And the balance shall equal E, or total vouchers paid. This must check with total disbursements as of pay roll closing date.

The material entries are for totals paid during the week, not for the value of the materials used in connection with the labor entries.

The revised estimate when properly kept up on the basis of costs to date is one of the most valuable features of the system. Immediately upon receiving an authorization for new work the constructing quartermaster has an estimate of work made and carried out in this column in the detail required for cost distribution, showing quantities and unit estimated costs. Further, as the work progresses, and the cost of the work has not been anticipated, a revised estimate should be made to supplant the original. In this way, knowing the percentage of completion, the constructing quartermaster has before him a detailed statement of his estimates.

No unit costs are required to be given weekly on small quantities such as concrete for foundations of frame structures, nor on overhead, prorate and indirect charges. Labor unit costs are required on those items of direct classification which are listed on the form (Fig. 238), and which items have quantities sufficiently large to justify the work involved. No labor unit costs are shown on such items as plumbing, lighting or heating while the job is in progress.

Chief among the unusual features of the system is the great number of items included under overhead, prorate and indirect charges, among which may be mentioned the unloading, loading and hauling of practically all materials and the cost of all temporary buildings, structures and roads, even when such temporary construction could be directly charged to one item of the work.

For example: A carload of material is received, unloaded and piled temporarily at the unloading plant; later it is hauled to a central storage yard; a part of it is then transferred to another storage yard or sub-depot from which point it is hauled to the proposed site of the job on which it is to be used. All expenses herein incurred, including the delivery at the site of the job, are charged to the overhead account and not to the job on which the material is to be used. Any expense incurred in connection with the distribution of plant and materials after delivery has been

made to the site of the job on which they are to be used is charged directly to the operation for which the materials are intended. An example of this is the carrying of wallboard into a building from the place where it was unloaded from wagon or truck at the door, which is charged to placing wallboard in that building. The costs of buildings, therefore, do not, until the overhead has been added to the other costs, include the item which contractors ordinarily call teaming.

On the other hand all expense of unloading and hauling materials required for the construction of pipe lines, pole lines, railroads, roads and like facilities is not charged as above, but is charged directly to the construction of the facility for which the material is handled.

Unless one realizes the large number of items included under overhead by the government, the high percentage of the overhead charge in government cost reports is likely to be surprising. This teaming item alone involves large expenditures. At Camp Beauregard, La., the overhead was so high as to cause 48% to be added to the cost of each piece of work done. This was not because of extravagance or carelessness, but simply because of the breadth of the classification.

A complete list of the items included under overhead prorate and indirect charges appears on the form Fig. 239. Accounts 152, 153, 155, 196 and 197 on this form consist only of that proportion of the expenses included therein, if any, which cannot be directly charged to accounts under direct construction cost.

In reference to some of these items the Cost Accounting Manual says:

> The theoretically correct method (but which method will not be used) of handling all charges in connection with use of equipment, which includes operation, rental, ordinary repairs and general repairs, is as follows:
>
> All charges for operation, rental and ordinary repairs should be charged to accounts set up to cover these expenses. General overhauling and repairs should be charged to an account "Repairs to Equipment," debited with the rate per hour or day, which will absorb and prorate these repairs over the entire work. The total charges to these equipment accounts should then be prorated to the items directly benefitted on the basis of the actual service hours as shown by the daily equipment reports. However, this method is not considered warranted under present construction conditions and charges shall be handled as indicated below.
>
> The operation, ordinary repairs (excluding trucks) and rental (excluding trucks) shall be charged directly against the specific item or items of work benefited thereby.

Major repairs and general overhauling shall be charged to items of work based on the probable total use of the equipment repaired.

Against the account 197, "Team Service," there shall also be charged the hire, feed and care of horses used on the job and which expenses cannot be charged against direct item of the work.

Trucks are hired on the various jobs under varying conditions, such as with or without driver and with or without gasoline, lubricants, and repair parts being supplied by the Constructing Quartermaster. It is therefore necessary to include operation and rental of trucks under on account.

The maintenance and repairs to trucks shall be charged to account 196, as trucks are used on a variety of work and it will be difficult to charge these expenses against the specific items of work on a correct basis.

166—Cleaning Up After Completion of Work: To this account there shall be charged all expenses incurred in connection with the cleaning up and disposing of refuse, waste material, etc., after the construction work is completed.

Any expense of this nature incurred during the progress of the work shall be charged directly to the secondary account number responsible for the accumulation of such waste. . . . .

No charge shall be made to this account for work done in any building until all the construction work in that building is finished.

To this account there shall also be charged all expenses incurred in connection with the disposal of waste material and the building construction.

Many of the cost engineers and contractors working for the government objected to this classification, the cost engineers because it did not follow the usual practice and the contractors because it makes the overhead percentage seem so high. The further objection was raised that since the total overhead is eventually to be divided among all jobs worked on at the place where the overhead was incurred, certain items will bear a very unfair percentage.

But the Cost Keeping Department felt that because of the many varying conditions met at the various projects it was impracticable to establish any exact basis of comparison of these expenses, and that it was essential that these expenses be kept as directed. A letter from the Chief of the Construction Division to all Constructing Quartermasters said:

Uniform results are the only results which will be of benefit to the Construction Division as a whole, and all units and all methods of obtaining costs should be the same; therefore, even though the costs submitted from a camp or project are excellent in themselves, if they do not conform to other projects they will not render the service expected. For this reason the cards sent you, the units suggested, and the methods outlined should be followed throughout, in order that all results may be uniform.

Equipment rental is carried on the pay roll. The equipment is checked every day and a proper record made of the work the different pieces of equipment are engaged on. The rentals are charged against the accounts in the same manner as other pay-roll items but idle or non-productive time of the equipment is charged to account number 155, idle equipment account.

It will be noticed that practically all of the details of this system relate only to labor costs. It was felt that, while one superintendent as compared with another or one project as compared with another project might make more or less saving in material, yet the difficulties of carrying the materials through stock accounts under existing conditions were too great to justify the work. The efficiency of construction work from the administrative viewpoint is determined by the labor unit costs.

While the material is not carried into the unit costs during the progress of the work yet strict account of it is supposed to be kept.

The material purchase order as placed is the basis for the distribution of material costs except where the material is not used as specified on the original purchase order. Exceptions to this rule may be the result of the following:

1. The placing of purchase orders for material in excess or the amount required in the construction of the project.

2. A change in plans, reducing the size of the project as a whole or the elimination of or reduction in size of certain parts.

Transfers of material are handled in the usual debit and credit manner.

Under ordinary conditions it is believed that carrying the material through the usual stock accounts is much more satisfactory than the method above outlined.

On most construction projects more than the regular number of working hours per day were being worked. For the additional time worked or overtime the rate of pay was generally more than straight time. This means that a certain number of hours and a certain amount of money were being paid in addition to the actual number of hours worked. Bonus Hours were defined by the "Cost Accounting Manual" as "the number of hours paid for in excess of the actual number of hours worked, or as that number of extra hours given to workmen as additional compensation for work performed on other than

regular working days or during hours other than those which constitute the regular working day."

Two examples are given below:

If the standard working day consists of 8 hr. and time and a half is allowed for overtime and 10 hr. are actually worked, the workman would receive pay for 11 hr. or a bonus of 1 hr. If a workman works 8 hr. on Sunday and time and a half is allowed for all Sunday work, the workman will receive pay for 12 hr. or a bonus of 4 hr.

In all projects a record of bonus hours and bonus money is kept under each employment, that is, trade or class of labor and rate of pay, showing the following data for both the current week and the total to date:

Rate per hour.
Total hours paid.
Total amount paid.
Total hours paid without bonus.
Total amount paid without bonus.
Total hours paid bonus.
Total amount paid bonus.
Percentage of pay roll.
Percentage of pay roll less bonus.

The items "Percentage of Pay Roll" and "Percentage of Pay Roll less Bonus" refer to the bonus, which shall be computed on the basis of hours as the money bears the same relation as the hours, and the hours will be smaller figures to use in computation.

The changed attitude toward the value of cost keeping is shown in the following paragraphs introductory to the cost manual:

> The importance of the keeping of cost analyses and unit costs has never been as generally recognized as at the present time. Never in the history of this Government has construction work been carried on under such conditions as exist today: Never has such a vast building program been undertaken as is now going on under the present extraordinary economic conditions.
>
> The prodigious increase in the cost of building materials and the existing unprecedented labor conditions emphasize the importance of cost analysis and the value of unit costs. . . . .
>
> Cost reports are essential for the following purposes:
>
> (*a*) To intelligently forecast the ultimate cost of the project during the process of the work.
>
> (*b*) To aid in the making of estimates on future work.

(c) To make possible such comparisons as may be desired on units, buildings or projects of like nature.

(d) To show unit labor costs during the progress of work and for the completed project; also to show total unit costs for all expenditures which include material and other charges in addition to labor, when project is completed.

(e) To enable this Division to compile such reports with reference to costs as may be desired or required by the Secretary of War, any Appropriation Committee or for the permanent records of the Construction Division.

Bridge Cost Record Used by the Illinois Highway Commission. The following is taken from *Engineering and Contracting*, Aug. 26, 1914:

The Illinois Highway Commission has prepared a "Bridge Cost Record" for use in keeping data in the field and in determining the final cost of its bridge work which greatly facilitates and systematizes this work. The record is in book form and contains 87 pages. It is 4½ by 7⅜ in. in size and has a flexible leather binding. Each inspector in charge of the construction of a bridge is given a copy of the record. In addition to keeping account of the quantities of materials and the costs, as outlined by the forms contained in the cost record, the inspector is required to mail to the office daily a report card showing the progress of the work. This report card is post card size.

The upper half of the first page of the record book contains the form for recording general data on the particular bridge under construction, the following data being recorded:

File No..................

Name of bridge..

County..

Township..

Span.................................Roadway....................

Type..

Inspector..

Contractor..

Time limit..

Pages 2, 3 and 4 are blank, and pages 5, 6, 7 and 8 contain the following set of "Instructions:"

As soon as work starts on the bridge assigned to you, fill in the blank spaces on the cover of this book with ink.

Diagram.—On the first page following these instructions, draw a diagram of the bridge showing the abutments, wings, footings, piers, girders and rails. Show the north point and direction of stream flow. Use the following abbreviations to denote the different parts of the structure:

N, S, E and W = north, south, east and west.
A = abutment.
W = wing.
f = footing.
P = pier; P1 = pier No. 1, etc.
S = span; S1 = span No. 1, etc.
F = floor; 1 = floor span No .1, etc.
G = girder.
R = rail.

By combining these abbreviations, each of the various parts of the bridge may be indicated as NAf = north abutment footing; NG1 = north girder span No. 1, etc.

The above system of abbreviations may be extended or diminished to suit the bridge in question and is to be used in the labor and material records for the purpose of designating the part of the structure on which the work is done.

Labor Record.—Under "Schedule of wages" at the bottom of the first page of the labor record, make a schedule showing the rate of pay per hour received by the various men employed on the work such as a = foreman at 60 cts. per hour; b = laborers at 25 cts. per hour; c = carpenters at 40 cts. per hour; etc. If the contractor pays the board of the men in addition to the daily wage, the cost of board to the men should be included in the rate of pay per hour. The daily labor record should show the part or parts of the work under way, the number of hours at each rate of pay and the total labor cost. The foreman's time should be distributed each day among the various items in proportion to the labor. For instance, if the schedule of pay is as given above and five laborers work 10 hr. each in excavating pier No. 1; three laborers work 10 hr. each driving sheet piles for pier No. 2, and two carpenters work 10 hr. each building forms for the south abutment, the day's record would be as follows: Opposite the item of "Dry" or "Wet excavation," as the case may be, would appear, P1, 50 b, 5 a = \$15.50. Opposite "Driving sheet piling" would appear P2, 30 b, 3 a = \$9.30; and opposite "Building forms" would appear SA, 20 c, 2 a = \$9.20.

Materials.—Under "Schedule for hauling" at the bottom of the first page of the "Material Record," make a schedule showing the rate per day or per unit of material for team hauling, using letters *x*, *y*, *z*, etc., to avoid confusion with the labor schedule. For instance, if the hauling is done by the day at \$4.50 for a 10-hr. day, at the bottom of the page would appear x = 45 cts. per hour per team. Then if on a given day three teams haul gravel for 10 hr. and deliver 3 yd. each, one team hauls cement 10 hr. and delivers 30 barrels; then in the day's record for hauling would appear opposite. "Cement Delivered" 30, $10x$ = \$4.50, and opposite "Gravel delivered" 9, $30x$ = \$13.50.

If the hauling is done at a certain rate per unit of material, as, for instance, 50 cts. per cubic yard for gravel, at the bottom of the page should

appear "Gravel hauled at 50 cts. per cubic yard," and it is not necessary to record for the day anything more than the number of units hauled and the total cost for the day.

If gravel, stone or sand is purchased or hauled by the ton, the equivalent number of cubic yards may be computed on the basis of 1 cu. yd. of gravel weighing 3,000 lb.; 1 cu. yd. of sand weighing 2,750 lb.; 1 cu. yd. of broken stone weighing 2,500 lb.

On a succeeding sheet under "Schedule" give the cost of materials at point where team haul begins.

Determine each day the amount of concrete placed by measurement in the forms and in the proper space record this amount and by abbreviations where used.

Record the amount of cement used each day and check against concrete placed, and amount required by the specifications for the material being used.

Falsework lumber includes piles or posts, bracing, wedges, beams and stringers. The lumber for the floor belongs under "Form lumber." If piling is used for the falsework, add a sufficient number of board feet to the rest of the falsework lumber to make up for the cost of the piling.

Permanent Piles.—The "Piling Record" refers to piles used as a part of the permanent work and should show the original length, cut off and net length of each pile, and should also show the total for each abutment and for each pier. The total lineal feet of permanent piling left in the ground for the entire bridge should be given at the end of the record.

Tests.—Record in a systematic manner all gravel and sand tests, tests on foundation and any other tests which you may make.

Instructions.—Record all suggestions given to the foreman or received from your division engineer.

Material Data.—The material data sheet is inserted to show in a concise form all data on materials. The cost should be for units of material. The column, "Name of Company Furnishing Same," should show the brand of cement and the name and address of the company furnishing stone, sand or gravel, and steel. For the other items, it will lbe sufficient to give the hauling station. Under "Remarks" give the hauing station or stations of the cement, stone, etc.

If the gravel is used from a local pit, make it a point to visit the pit at some convenient time and give a description of the same on the preceding blank page, giving location, name of owner, a rough estimate of the available gravel in pit, etc.

Detail Cost Summary.—As soon as the work is finished, with the exception of removing the falsework, fill out the detail cost sheets at the end of the book with pencil. Each item of cost should include all items that may properly be included thereunder, as, for instance, cost of pumping during excavation should include cost of rigging of pump, fuel, etc., and cost of driving piling should include cost of rigging up driver, removing same, etc.

The item, "Labor Removing Falsework," will have to be estimated in most cases, as you will probably not be on the job when this work is done.

The item, "Incidentals," should include only such items as cannot properly be applied to the detail work items. Incidentals, extras, traveling expenses, etc., are to be distributed among the cost per cubic yard items as

may seem most appropriate, giving in the detail items an indication of the distribution.

The salvage on lumber and falsework is an item subject to considerable variation. It depends mostly upon the dimensions and quality of the lumber and the complication of the form work. If the contractor has work on which the lumber will be used several times, this should be taken into consideration in figuring salvage. For instance, if the form lumber can be used on three different jobs, the salvage would be 67% less the value of the lumber wasted. If, however, the contractor buys new lumber and sells it when the work is finished, the salvage would be the selling price of the lumber which might not be more than 15%.

Date....................	....	....	....
Removing old bridge	....	....	....
Dry excavation............	....	....	....
Wet excavation...........	....	....	....
Driving sheet piles.........	....	....	....
Pulling sheet piles..........	....	....	....
Pumping while excavating ..	....	....	....
Pumping while concreting...	....	....	....
Driving bearing piles.......	....	....	....
Building forms............	....	....	....
Bending and placing steel...	....	....	....
Mixing and placing concrete.	....	....	....
Building falsework	....	....	....
Removing forms	......	....	....
Removing falsework........	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
Total..................	....	....	....
Schedule of wages..........	....	....	....

FIG. 240.—Left-hand page of form for labor record.

In summarizing the cost per cubic yard of concrete, each item in the summary should include all of the detail items that properly belong in the summary item. For instance, forms per cubic yard of concrete should include lumber, nails, wire, etc., and excavation should include cost of sheet piling, excavation, pumping, etc.

Disposal of Records.—When your cost record is complete, mail the book together with the plans, to your division engineer. He will check the same and return the book to you for corrections if any are necessary, and you should then letter with ink the four detailed cost sheets. The other data may be in pencil, but do not use a softer pencil than a 4H. After inking on the cost sheets, send the book to the office. Have this book with you

on the job at all times so that your division engineer may examine it when he comes to visit the work.

If in doubt about anything, ask your division engineer.

Pages 9 and 10 are blank, and on page 11 there is the following

ITEM	DATE 191							Total for Week	Total Deliv'd
Concrete placed cu. yds.									
Cement used bbls.									
Cement del. bbls.									
Stone del. cu. yds.									
Sand del. cu. yds.									
Gravel del. cu. yds.									
Steel del. lbs.									
Form lumber del. M ft. B. M.									
Piling del. No.									
Sheet piling del. M ft. B. M.									
Falsework timber del. M ft. B. M.									
Schedule for hauling									

FIG. 241.—Form for material record.

heading: "Plan of Bridge, Showing Abbreviations to Be Used on Labor Sheets," with space below for recording these data.

Pages 12 and 13, to 34 and 35, inclusive, which face each other contain duplicate forms for making out the "Labor Record." The left-hand page contains the data shown in Fig. 240. The

right-hand page is ruled in a similar manner, the last column of which has the heading "Total."

Pages 36 to 47, inclusive, contain duplicate forms for recording the "Material Record." Each form fills one page and is made up as shown in Fig. 241.

The forms for keeping the "Piling Record" data are given on pages 50, 51, 52 and 53. Each page is divided into four columns by vertical lines, the heading for these columns being

Material	Cost		Name of Company Furnishing Same
	At R. R. Station	At Bridge	
Cement	....	....	....
Stone........	....	....	....
Sand.........	....	....	....
Gravel.......	....	....	....
Steel........	....	....	....
Piling.......	....	....	....
Form lumber..	....	....	....
Sheet piling...	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
Remarks:			
....			
....			
....			
....			

FIG. 242.—Form for material data.

"Pile No.," "Length," "Cut Off," and "Net Length." Each page contains space for 25 pile records.

From page 54 to page 74, inclusive, there are given blank spaces for recording such items as: Bearing Tests on Foundation (3 pages); Gravel and Sand Tests (3 pages); Suggestions Given to Foreman (4 pages, ruled horizontally); Instruction from Division Engineer (4 pages, ruled horizontally); and 7 blank pages.

On page 75 there is given a "Material Data" form which is made up as shown in Fig. 242.

On pages 76, 77, 78 and 79 there is given a form for determining the "Detail Cost of Bridge Work—Actual Cost." In the cost

Cement	......bbls.	@ $......	per bbl.	= $......
Hauling cement	......miles	@ $......	per bbl.	= $......
Crushed stone	......cu. yds.	@ $......	per cu. yd.	= $......
Hauling crushed stone	......miles	@ $......	per cu. yd.	= $......
Sand	......cu. yds.	@ $......	per cu. yd.	= $......
Washing sand	......cu. yds.	@ $......	per cu. yd.	= $......
Hauling sand	......miles	@ $......	per cu. yd.	= $......
Gravel	......cu. yds.	@ $......	per cu. yd.	= $......
Washing gravel	......cu. yds.	@ $......	per cu. yd.	= $......
Screening gravel	......cu. yds.	@ $......	per cu. yd.	= $......
Hauling gravel	......miles	@ $......	per cu. yd.	= $......
Form lumber	......M. ft. B. M.	@ $......	per M.	= $......
Falsework lumber	......M. ft. B. M.	@ $......	per M.	= $......
Wire, nails, etc.	......lbs.	@ $......	per cwt.	= $......
Hauling form lumber	......miles	@ $......	per M.	= $......
Hauling falsework lumber	......miles	@ $......	per M.	= $......
Reinforcing steel	......lbs.	@ $......	per cwt.	= $......
Hauling steel	......miles	@ $......	per cwt.	= $......
Rockers	......lbs.	@ $......	per cwt.	= $......
Asphalt	......gals.	@ $......	per gal.	= $......
Hauling rockers and asphalt	......miles	@ $......	per day	= $......
........round piles at bridge site	......ft. long	@ $......	per pile	= $......
Cost of driving piling	......lin. ft.	@ $......	per linear foot	= $......
Sheet piling	......M. ft. B. M.	@ $......	per M.	= $......
Hauling sheet piling	......miles	@ $......	per M.	= $......
Cost of driving			......M. ft. B. M. of sheet piling	= $......
Cost of removing			......M. ft. B. M. of sheet piling	= $......
Labor on......cu. yds. dry earth exc.	......hrs.	@ $......	per cu. yd.	= $......
Labor on......cu. yds. wet earth exc.	......hrs.	@ $......	per cu. yd.	= $......
Cost of pumping during exc.	......hrs.	@ $......	per hr.	= $......
Cost of pumping during conc.	......hrs.	@ $......	per hr.	= $......
Labor building forms	......hrs.	@ $......	per hr.	= $......
Labor building falsework	......hrs.	@ $......	per hr.	= $......
Labor bending and placing steel	......lbs.	@ $......	per cwt.	= $......
Labor mixing and placing concrete	......hrs.	@ $......	per hr.	= $......
Labor removing forms	......hrs.	@ $......	per hr.	= $......
Labor removing falsework	......hrs.	@ $......	per hr.	= $......
Traveling expenses				= $......
Extras				= $......
Extras				= $......
Incidentals				= $......
......		......		......
......		......		......
				Total......
Salvage on lumber and falsework				= $......
Total net cost to contractor				= $......
Total amount due contractor				= $......
Profit or loss				= $......

FIG. 243.—Form for detail cost of bridge work—actual cost.

record book the item and the quantity are on the left-hand page and the unit and total cost on the right-hand page. This form is made up as shown in Fig. 243.

Summation of cost per cu. yd. for placing...... cu. yds. of concrete and......... pounds of steel.

This does not include cost of round piling, expansion rockers, or removing old bridge.

					Cost per cu. yd. of concrete.
Cement	........bbls.	@ $........	per bbl.	=	$........
Stone	........cu. yds.	@ $........	per cu. yd.	=	$........
Sand	........cu. yds.	@ $........	per cu. yd.	=	$........
Gravel	........cu. yds.	@ $........	per cu. yd.	=	$........
Labor on forms per cu. yd. of concrete........			....	=	$........
Form materials per cu. yd. of concrete........			....	=	$........
Labor on falsework per cu. yd. of concrete........			....	=	$........
Falsework materials per cu. yd. of concrete........			....	=	$........
Cost of steel in place per cu. yd. of concrete........			....	=	$........
Cost of mixing and placing concrete........			....	=	$........
Cost of excavation per cu. yd. of concrete........			....	=	$........
			Total	=	$........
Cost of exc. per cu. yd. of substr. concrete........			....	=	$........
Cost of falsework per cu. yd. of superstr. conc........			....	=	$........
Cost of removing old bridge........			....	=	$........
(Give brief description of old bridge.)					

Fig. 244.—Form for cost per cubic yard.

Pages 80 and 81 contain the "Cost Per Cubic Yard" form. This form occupies both the left-hand and the right-hand pages, a small space being left at the bottom of the pages for a brief description of the old bridge. This form is shown in Fig. 244.

Concrete shown on plans........	Superstr........cu. yds.	Substr........cu. yds.
Reinforcing steel shown on plans........	Superstr........ lbs.	Substr........ lbs.
Concrete actually used........	Superstr........cu. yds.	Substr........cu. yds.
Reinforcing steel actually used........	Superstr........ lbs.	Substr........ lbs.
Extra concrete authorized in superstr........	19........	........cu. yds.
Extra concrete authorized in substr........	19........	........cu. yds.
Reduction in concrete authorized in superstr........	19........	........cu. yds.
Reduction in concrete authorized in substr........	19........	........cu. yds.
Piling authorized	19........	........lin. ft.
....	....	....
....	....	....
....	....	....

Fig. 245.—Form for summary of quantities.

On the upper half of pages 82 and 83, extending across both pages, there is given the form for the "Summary of Quantities." This form is shown in Fig. 245.

The lower half of pages 82 and 83 contain the form for "Payments Recommended." This form extends across both pages and is made up as shown in Fig. 246.

Pages 84, 85, 86 and 87 are blank pages.

Daily Report Form.—The form used by the inspectors in making out their daily report is shown in Fig. 247. The form is post card size ($3\frac{1}{4}$ by $5\frac{1}{2}$ in.), and contains on the opposite side of the commission address and a space for a 1-ct. stamp.

Cost Recording Forms Used for Street and Sewer Work, Engineering Department, Spokane, Wash.—The following notes are taken from *Engineeriny and Contracting*, Nov. 22, 1911.

The accompanying forms show the manner of recording labor and material consumed in street improvement and sewer construction in Spokane, Wash. These forms have been worked up by the city engineering departments, Morton Macartney, city engineer. Mr. Macartney describes the forms (Figs. 298–251) and their purpose as follows:

There are four forms, namely: Two inspector's daily report forms, and two monthly record forms, one each covering street work and one each covering sewer work. The inspector's reports are made out daily by the inspectors on the work and are turned in to the office either the night of the day reported, or the first thing the following morning. It will be noted that they go into detail to considerable extent, but it is found that with a printed form of this kind the inspector has no difficulty in segregating the work and putting the proper entries on same. The forms are tabulated and arranged so that the inspector does as little writing as possible. This accounts somewhat for their size.

These daily reports are turned in to a clerk in the department, who enters them upon the monthly reports. These monthly reports are kept, one for each improvement, and by "improvement" is meant the entire contract for a given street. These are turned in to the district engineers, who verify and certify to their correctness, and are then passed to the chief. After they have been corrected and tabulated, they are place in the file for this improvement. In this manner it has been possible to get very accurate and reliable cost data on work.

There has been some difficulty in keeping the inspectors lined up to report accurately the items, and probably the cost data varies from the actual cost 5% but it is not believed that there is ever any variation to exceed this. The district engineers go over

Contract price superstructure....................	Dollars ($............)
Extras superstructure	Dollars ($............)
Contract price substructure....................	Dollars ($............)
....cu. yds. extra concrete @ ($....) per cu. yd....................	Dollars ($............)
......lin. ft. piling @ ($......) per lin ft....................	Dollars ($............)
....,....................	....
....	....
Total....	$............
...cu. yds. reduction in conc. @ ($...) per cu. yd....................	Dollars ($............)
Net amt. due contractor	Dollars ($............)

FIG. 246.—Form for payments recommended.

......................Br. 1914
Tp..................County....................

INSPECTOR'S DAILY REPORT.

KIND OF WORK	No. of Hrs. Work	Percent Completed	Remarks
Excavating......	....	....	....
Abutment......	....	....	....
Abutment......	....	....	....
Pier..........	....	....	....
Pier..........	....	....	....
Erecting Forms..	....	....	....
Abutment......	....	....	....
Abutment......	....	....	....
Pier..........	....	....	....
Pier..........	....	....	....
Floor	....	....	....
Girder	....	....	....
Placing Rods....	....	....	....
....	....	....	....
Concreting	....	....	....
Abutment......	....	....	....
Abutment......	....	....	....
Pier..........	....	....	....
Pier..........	....	....	....
Floor	....	....	....
Girder.........	....	....	....
Building False Wk	....	....	....
Removing Same..	....	....	....
Pumping........	....	....	....
Hauling Material	....	....	....
Team and Man ..	....	....	....
....	....	....	....
Removing Forms	....	....	....
Finishing........	....	....	....

Material on Ground	Sand	Gvl.	Stone	St'l Rods	Bridge Material
....	....		....		....
Total Men Working..........	....		....		....
Con. of Stream...	....		....		....
Con. of Work....	....		....		....

....................P. O. ....Inspector

FIG. 247.—Form for inspector's daily report.

Form 105.

INSTRUCTIONS

Make separate reports for Car Tracks.
Use Square Yards for Sidewalks and Pavements.
Use Linear Feet for Curbs and Cross Walks.
Use Number of Sacks, when reporting Cement used.
Private work, means anything not called for in specifications, such as driveways, etc.

ENGINEERING DEPARTMENT
Daily Force Report

Improvement ____________
From ____________
To ____________
Location ____________
Contractor ____________

Spokane, Wash., ____________ 191__

	RATE	GRADE Hours	WALK Hours	CURB Hours	C. CURB & GUTTER Hours	CROSS WALKS Hours	PAVING Hours	WALL Hours
Foreman								
Formsetter								
Laborers								
Finishers								
Helpers								
Rakers								
Masons								
Engineers								
Firemen								
Teamsters								
Teams								
S'gl Horses								
Mixers								
St'm R'llers								
St'm Drills								
Drillers								
Blacksmith								
Powderman								
Powder								

	AMOUNT	SACKS CEMENT	BRAND CEMENT	GALLONS OIL	PRIVATE WORK		
					Amt.	Sacks Cement	Brand Cement
Sidewalks							
Curbs							
C.C'rb&Gutt'r.							
CrossWalks							
C'ncrt on Base							
Brick Gutt'r							
Brick P'v'g.							
Asphalt T'p							
Asph'lt B'dr							
M'c'd'mT'p.							
M'c'd'mBse							

Cement—Rec'd ______ Tested on hand ______ Untested on hand ______

Certified correct ____________
Inspector

INLAND PTG. CO

FIG. 248.

FORM 177

CITY OF SPOKANE

SEWER INSPECTORS DAILY FORCE REPORT

Date ______________ 191

Imp'mt: ______________________________

____

Contractor ______________________________

WORKMEN	Rate Per Hour	Number of Hours: Sewer Proper Including Back-Fill: M. H. No.___ To M. H. No.___ V. P.	M. H. No.___ To M. H. No.___ V. P.	M. H. No.___ To M. H. No.___ V. P.	M. H. No.___ To M. H. No.___ V. P.	On H. C. Between M. H. No.___ and M. H. No.___
Foreman						
Pipe Layer						
Pipe Layer Helper						
Blacksmith						
Blacksmith Helper						
Timberman						
Powderman						
Powderman Helper						
Laborer						
Teamster and Team						
Firemen						
Hand Driller						
Machine Driller						
No. Feet Drilled						
Sacks Cement used for Joints						
Pounds of Powder used						

Signed ______________________________ Inspector

(Over)

FIG. 249.

	For M. H. No.____	For F. T. No.____	For C. B. at M. H. No.____
Sacks of Cement____			
Cubic Yards of Sand____			
Cubic Yards of Rock____			
Number of Brick____			
Feet of Vitrified Pipe____			
Feet of Water Pipe____			
Laborers____	____Hrs.	____Hrs.	____Hrs.
Mason____	____Hrs.	____Hrs.	____Hrs.
Mason Helper____	____Hrs.	____Hrs.	____Hrs.

For House Connections From M. H. No.____to M. H. No.____

____Ft.____In. Vitrified Pipe.

Remarks____

Fig. 249a.

File No. .... ENGINEERING DEPARTMENT. City of Spokane, Washington. STREET DIVISION.

District Engineer's Estimate Improvement of .... *Time Report of Contractor's Force, Month of* ....*191*........

Percentage of Excavation........................ From ....Contractor........................

Percentage of Embankment........................

Percentage of Total Work........................ To .... Roll Confirmed ....Work Started........................Delinquent........................

Force	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total	Rate	Amount
Foremen																																		
Laborers																																		
Teamsters																																		
Teams																																		
Powder																																		
Totals																																		

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total this Month	Amt. Brought Forward	Total to Date
Sq. Yds. Walk																																		
Sacks Cement																																		
Lin. Ft. Curb																																		
Sacks Cement																																		
Lin. Ft. C. C. and Gutter																																		
Sacks Cement																																		
Lin. Ft. Cross Walk																																		
Sacks Cement																																		
Sq. Yds. Con. Base																																		
Sacks Cement																																		
Paving																																		
Sacks Cement																																		

Correct........................*Clerk*. ....*District Engineer.*

FIG. 250.

File No...................... Engineering Department. CITY OF SPOKANE. Sewer Divisinn.

Material and Labor Report on PIPE SEWERS for Month of..191.......... On the Sewer Improvement

Assessment Roll Confirmed ....191......... Work Started ....191 .... Contract Delinquent...................191.......... ....Contractor

Force	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total	Rate	Amount
																						Brought Forward												
Foremen..........																																		
Laborers																																		
Pipe Layers..........																																		
" " Helpers...																																		
Masons..........																																		
" Helpers.......																																		
Blacksmiths..........																																		
" Helpers....																																		
Timbermen..........																																		
Powdermen..........																																		
" Helpers...																																		
Teams..........																																		
Teamsters..........																																		
Drillers (Hand).......																																		
" (Machine)....																																		
Firemen..........																																		
Machine Drills.......																																		
Total for Month......																																		
Total to Date........																																		

Lineal Feet Vitrified Pipe		
8"		8"
10"		10"
12"		12"
15"		15"
18"		18"
21"		21"
24"		24"
30"		30"
Lineal Feet ¾" Water Pipe		
Excavation for Month Lin. Ft. Trench		
Solid Rock		
Loose Rock		
Hard Pan		
Gravel		
Lin. Ft. Trench Backfilled		
Percentage of Contract Finished		

Std. M. H.		Drop M. H.		Flush Tanks		Catch Basins		Number Brick	Sacks Cement	Yards Sand	Yards Crushed Rock	Powder	Exploders	Engineering Expense-Office	Engineering Expense-Field	Inspection Expense
No.	Lin. Ft.	No.	Lin. Ft.	No.	Lin. Ft.	No.	Lin. Ft.							Month $.........	Month $.........	Month $.........
														Total $.........	Total $.........	Total $.........

REMARKS

....Clerk ....District Engineer

Fig. 251.

the reports every day and are over their work every day, so that no great discrepancies could get in. In addition to this, the contractors are paid a lump sum for the completed improvement rather than unit prices for the different segregated pieces of work. In this way the contractors have no object in influencing the inspectors to change the quantities materially. There is also a check in the city laboratories on the amount of cement used, as well as preliminary estimates made before the work starts.

In addition to the forms heretofore mentioned, which are strictly force account forms, all employes in this department are required to sign a time card, shown by Fig. 252.

FORM 176

CITY OF SPOKANE—ENGINEERING DIVISION

DAILY TIME REPORT

Name____________________Date________________191__

Profile No.	Improvement	From	To	Hrs.		

NOTE:—Time Slips must be filled out properly and turned in daily. Unless complied with, no time will be allowed.

FIG. 252.

Cost-keeping System for Small Bridge and Culvert Jobs.—The following notes are taken from *Engineering and Contracting*, June 27, 1917.

A cost-keeping system particularly well adapted to the small and scattered culvert and bridge jobs encountered in county work in Iowa is employed by J. A. Dunkel, Contractor, Webster City, Iowa.

The foreman makes a daily report on labor, progres and materials, the blank shown in Fig. 253 being used for this purpose. This report shows the labor hours distributed to all the kinds of work done, all materials received and used, and empty sacks returned. The report gives a good check each day on all items, and permits the making of a comparison of the cost of each on

different jobs. The foremen on the different jobs are furnished the labor costs for all jobs each month and they knowing what

DAILY REPORT

Kind of Bridge ....

Location ....

Size .... LABOR – PROGRESS – MATERIAL Job No. .... Date .... 191 .....

NAME	Moving	Dry Excavation	Wet Excavation	Pumping	Building Forms	Mixing	Setting Bars	Bending Bars	Cutting Bars	Setting Up	Temporary Crossings	Trimming Piling	Driving Piling	Repairing Tools	Repairing Work	Cut. Off Piling	Driving Sheeting	Removing Forms	Cleaning Forms	TOTAL HOURS	RATE
	Depth Excavated	Yards Dry Excavation	Yards Wet Excavation	Loads of Stone Received	Loads of Gravel Received	Yards Concrete Poured	Sacks Cement Received	Sacks Cement Used	Empty Sacks Returned	Empty Sacks On Hand	Sacks Cement On Hand	No. Pieces Piling Received	No. Feet Piling Received	No. Feet Piling Driven	No. Pieces Piling Driven	No. Feet Cut Off	Length of Sheeting	No. Pieces Sheeting			

NOTE—LIST ALL OTHER MATERIALS HERE AND ATTACH DELIVERY TICKET

J. A. DUNKEL, CONTRACTOR
WEBSTER CITY, IOWA

FOREMAN

ADDRESS

FIG. 253.—Form for foreman's daily labor, progress and material report. Actual size of blank 7¾ × 9¾ in.

J. A. DUNKEL
GENERAL CONTRACTOR
WEBSTER CITY, IOWA

DAILY BRIDGE TEAM/TRUCK HAULING & EXPENSE RECORD

______________ 191__

LOAD OF	FROM	TO	WEIGHT	MILES	HRS	ARTICLE	AMOUNT		WHERE BOUGHT
						GAS			
						OIL			
						GREASE			
						CORN			
						HAY			
						OATS			
						STRAW			
						REPAIRS			
									TOTAL EXPENSE FOR DAY
									TOTAL CARRIED FORWARD
									TOTAL EXPENSE TO DATE

TICKETS MUST BE ATTACHED FOR ALL EXPENSE INCURRED

REMARKS—CAUSE OF DELAY, ETC.

______________ DRIVER

FIG. 254.—Daily hauling and expense record. Actual size 7¼ × 8½ in.

the other men are doing they are supplied with an incentive to reduce their own costs when possible.

Bills for materials and supplies, also duplicates of material orders are attached to each daily report. As the jobs are small Mr. Dunkel finds that it works very satisfactorily for teamsters and truck drivers to make their own reports. They keep an account of all expenses and attach bills for all items to their report. The blank used for this purpose is illustrated as Fig. 254.

J. A. Dunkel, Contractor
WEBSTER CITY, IOWA

Date.................................191..

I have today purchased and received from

....

....

HAY	..........tons	..........lbs.			
STRAW	..........tons	..........lbs.			
CORN	..........bu.	..........lbs.			
OATS	..........bu.	..........lbs.			
Shoeing					
Wagon Repairs					
Harness Repairs					
Grease					

....Teamster

Ticket O. K...

Payment Received...

Weigh Tickets Must Be Attached

FIG. 255.—Purchase ticket. Actual size $5\frac{3}{4} \times 3\frac{1}{2}$ in.

The form employed for purchases is shown as Fig. 255. Previous to the use of this ticket it was found that many small items of feed, etc., were not turned in at the time the purchase was made. This caused trouble as bills sometimes turned up months afterward. Under the present system when anything is purchased a copy of the ticket is given as a receipt and another copy is attached to the teamster's report. The use of this ticket makes considerable saving each month in the purchases.

As the work is in the country with sometimes five moves per month, Mr. Dunkel uses wagon camps, one for cooking and dining room and one for sleeping quarters. The men are paid on the hourly basis with deductions for meals. The boarding account is kept separate and is checked up each month so that the contractor knows exactly how he stands.

J. A. DUNKEL, CONTRACTOR
WEBSTER CITY, IOWA

Date..191....

MATERIAL ORDER

JOB NO.................

Deliver the following materials or supplies to

.. Teamster

and charge same to the account of J. A. Dunkel

....
Foreman

FIG. 256.—Material order. Actual size 8 × 3½ in.

Accounting and Cost Methods for Contractors.[1]—There are two ideas extant regarding the keeping of records by contractors. The one is put forth by a class of accountants who are bookkeepers and nothing else. They regard any work done by men who are not trained in bookkeeping to be an unwarranted infringement on their rights, and claim no one should attempt to make records of a financial transaction except a man of experience in ordinary accounting methods. The other idea regarding the keeping of accounts on contracting jobs is put forth by men of practical experience, who hold that every man on the job who is in a responsible position and can write, should send in a daily record of his work, even if he does not know how to keep books.

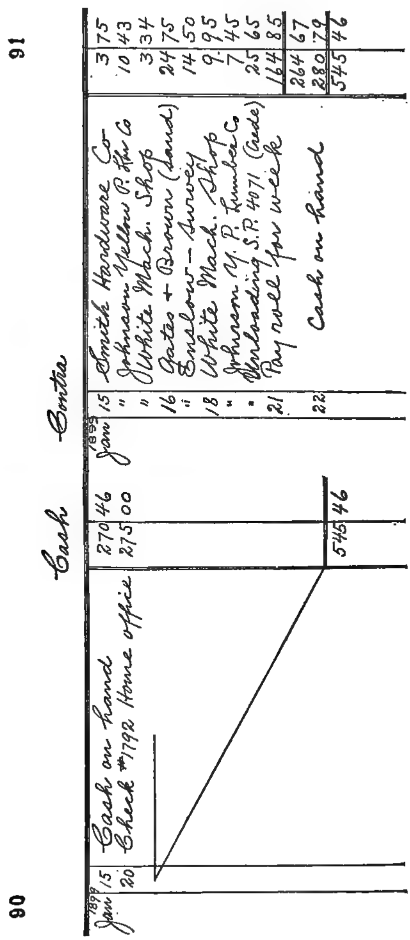
[1]Ernest McCullough in Engineering and Contracting, Sept. 1, 8, 15, 22, 1909.

One thing exists in common between the warring factions, and that is that forms are required. Of the two, the bookkeeper gets out the most involved. The man without experience in account-keeping gets out forms containing, as a rule, too much detail, but his forms, at any rate, have the merit of being understandable by the average man. Unfortunately, in these days of vertical files and card indexes and business men's magazines and industrial literature generally, a great many amateur form-makers have been working. The preparation of a set of forms to give a man all the information he requires for his business, is not a matter of engaging a form-maker for a few days or hours to turn out a system full fledged. Forms must be tried out on work and changed many times before they finally get down into shape. It is a mistake too often made that each particular business must have forms differing from those used in other lines of work. It is possible to have a practical uniformity about such methods, so that a set of forms used in one place can do in another, and forms prepared for one line of work can be used in another. There may be some difference in some of the details, but it should not go further.

The writer's habit has been to make forms on mimeograph or hektograph and try them out, making changes frequently until by the time a job was completed a form would be worked out, and then when a similar job came up the form for it was ready. Finally, after a number of years of experience in handling work personally, and by means of foremen sent off to distant parts, he worked up a system for small pieces of work that has been very satisfactory in his own case.

In the first place comes the cash book. This is very important. He has had young fellows who took courses in business college, who actually did not know a simple method of keeping track of money spent and money received and how to balance the book. No matter how many forms are devised, the cash book cannot be dispensed with. The size of the page matters little, but for the sake of uniformity and the filing away of books, etc., he prefers a cash book having a page practically 6 by 9 in. in size, ruled for single entry. Upon the left-hand page enter all money received, and upon the right-hand page enter all money expended. Figure 257 shows the appearance of a cash book used on one job, with the names changed. These pages illustrated give the account for 1 week. It is presumed

that a report will be made out each pay day evening to the home office, and the report for the week shown on the cash book pages is given in Fig. 258. The report is made on a sheet of paper purchasable at any stationery store.



90 — Cash

1899 Jan. 15	Cash on hand	270 46
20	Check #1792 Home office	275 00
		545 46

91 — Contra

1899 Jan. 15	Smith Hardware Co	3 75
"	Johnson Yellow P. Lu. Co	10 43
"	White Mach. Shop	3 37
16	Gates + Brown (sand)	24 75
"	Enslow—Survey	14 50
18	White Mach. Shop	9 95
"	Johnson Y. P. Lumber Co	7 45
"	Unloading S.P. 4071 (Ende)	25 65
21	Payroll for week	164 85
		264 67
22	Cash on hand	280 79
		545 46

FIG. 257.—Pages in single entry cash book.

One book will do on almost any job of the ordinary size that one man will be sent away to take care of. The habit of the writer is to buy a book containing about 180 pages. The job has to be completed within a certain number of weeks. For instance, some job we are now considering will take 30 weeks.

Reserve all the pages up to page 70 for cash accounts. The cash received will occupy one page and the cash paid out will occupy the facing page. Therefore, for each week there will be two pages reserved, and a few can be added in case the job overruns the time. Even if the cash items only take a few lines, it is well to give the whole page to the week's items, as it looks neater and allows of the making of entries afterwards in case the

Cash Report.

Brownson Power Plant, Week ending Jan. 21-99

		Cash.				
Jan	15	On hand			$270	46
	20	Check #1792 Home office			275	00
		Disbursements.				
Jan	15	Smith Hardware Co	$3	75		
	"	Johnson Yellow Pine Lbr Co.	10	43		
	"	White Mach Shop	3	34		
	16	Gates + Brown, sand	24	75		
	"	Enslow - Survey	14	50		
	18	White Mach shop	9	95		
	"	Johnson Y.P. Lbr Co	7	45		
	"	Unloading S.P. 4071 (Crede)	25	65		
	21	Payroll for week	164	85		
			264	67		
		Cash on hand	280	79		
			545	46	545	46

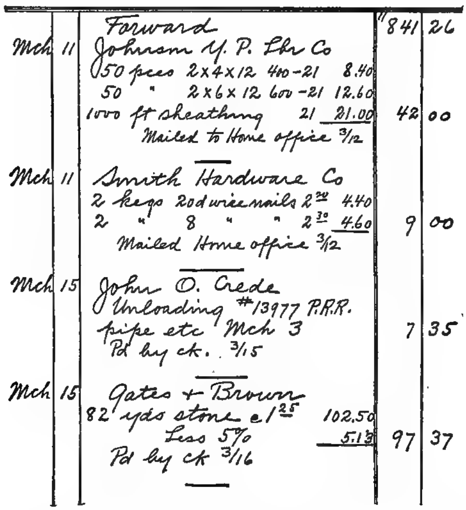
E. & O.E.
Bert Johnson
Foreman

FIG. 258.—Weekly cash report from cash book.

books are gone over to get unit costs, etc. On the job shown here here was supposed to be a cash balance in the bank at all times of not less than $200, and a check for the weekly pay roll was sent on from headquarters in time to take care of pay day, which was Saturday.

Having reserved for the cash account a little over double the number of pages it is estimated the job will last weeks, the remaining pages are used for keeping track of bills received.

Each bill is copied in full the day it is received. Figure 259 shows how a page looks. These bills should be copied in full daily and mailed to the home office with the daily work report. There should be no delay in doing this work. The experience of the writer, and of every employer of men, has been that if things like this are not attended to daily they will be neglected and at the final moment there will be a rush. A man who will not do this work daily should be discharged. There is no excuse. A few minutes' work each day saves a great deal of worry and bad work before the job is completed. The home office always wants the original bills. Very many times a home



		Forward	841	26
Mch	11	Johnson Y. P. Lbr Co		
		50 pces 2x4x12 400-21 8.40		
		50 " 2x6x12 600-21 12.60		
		1000 ft sheathing 21 21.00	42	00
		Mailed to Home office 3/12		
Mch	11	Smith Hardware Co		
		2 kegs 20d wire nails $2^{\underline{20}}$ 4.40		
		2 " 8 " " $2^{\underline{30}}$ 4.60	9	00
		Mailed Home office 3/12		
Mch	15	John O. Crede		
		Unloading #13977 P.R.R.		
		pipe etc Mch 3	7	35
		Pd by ck. 3/15		
Mch	15	Gates + Brown		
		82 yds stone @ $1^{\underline{25}}$ 102.50		
		Less 5% 5.13	97	37
		Pd by ck 3/16		

FIG. 259.—Page from book containing copies of bills.

office does not see why the man on the job needs any copies of bills at all. Invariably when a dispute arises the home office appeals to the man on the job, and it is a fine thing for him to have a record.

Instead of going to the trouble of copying these bills, it is required by some firms that duplicate bills be obtained for all purchases. There are some objections to this. Many time purchases are made for cash, and to delay while the slow-moving bookkeeper makes out a duplicate bill, might cost more dollars in lost time than it is worth. Take the cash slip and go. A great many firms, especially in the smaller towns, never make a

habit of giving duplicate bills, and to ask for them causes bother and delay. Very often they are not given and then some part of the account is lost. Duplicate bills are a source of great annoyance nine times out of ten, and very often a first-class foreman becomes poor in looking after his regular work because of the time consumed in looking after the accounts. The duplicate bill idea is good if it were the habit of every business house to make them out. In one town a small contractor was told by one house that his business amounted to so little that they did not care to keep it if they had to remember every time to make out duplicate bills for every little purchase he made.

Duplicate bills are pasted in invoice books or put in letter files, and when the inevitable inquiry comes from the bookkeeper in the home office, the particular bill wanted is often missing.

Shipped	Consignor	Material	Car	Received	Unloaded	Freight		Demurrage		Switching		Remarks
						Amt.	Billed	Amt.	Billed	Amt.	Billed	

Fig. 260.—Double page ruling for carload freight shipments.

It does happen sometimes that mail is lost or destroyed, and the importance of having copies of all papers should not be overlooked. The writer is very firmly impressed with the value of a hand-made copy of every bill received. These bills should be sent to the home office every night in order that there will be no accumulation.

In the back of the book there should be a record of carload freight received. It is usually easy to tell in advance about how many carloads of material will be received. Counting one line for each car record, count off twice as many lines (for sometimes things turn out differently from what was expected), and rule up the pages covered by these lines as shown in Fig. 260.

These pages can be the very last pages in the book. The book will then hold a complete record of cash received and expended on the job; a complete record of all bills received and the dis-

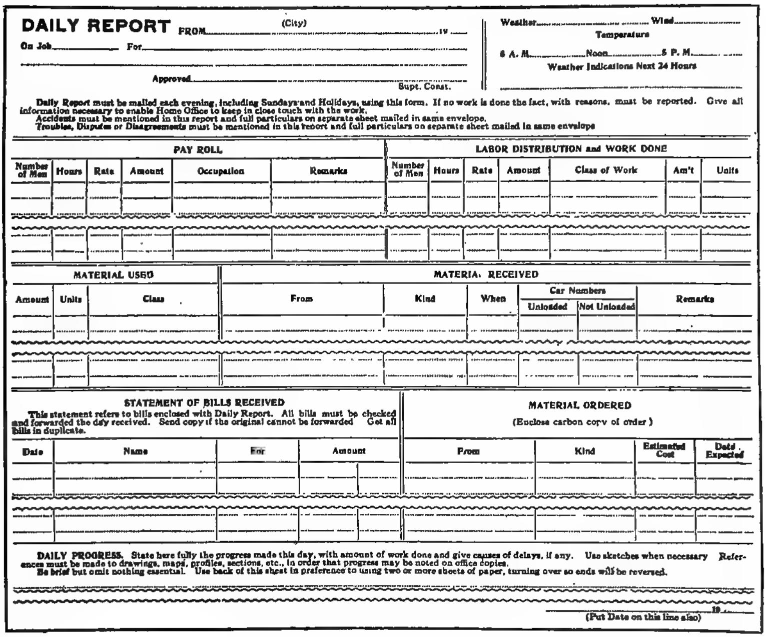
position made of the bills; a complete record of freight receipts in carloads. This makes a complete and satisfactory log of the job, and the average contractor will find such a record a good thing to have.

It usually happens that a number of blank pages are left in the book when the job is completed. The writer, therefore, completes his books by writing in them, after everything is cleaned up, a concise history of the job. The first page is used as an index and here he indexes the items so that they can be referred to. In this history he records how the job was secured, pasting in clippings, if they will help, gives some idea of conditions encountered, the weather, the satisfaction given by the foreman, etc., and whether a profit was made or a loss sustained. If a profit, then the places on the work where it was made; if a loss, then some ideas are given as to why loss was incurred and the lessons learned. This looks like a great deal to place in the one little book, but it is simplicity itself when started, and a book for each job gives a man a splendid record of a life's work. It very seldom happens that the head office ever considers that a man has such records, therefore the general run of foremen are at perfect liberty to keep them, and in this way reduce their experience to writing for guidance in future work.

The daily record is an important subject. The writer has used the form here given (Fig. 261) for a number of years. He has been employed by firms that asked him not to bother sending in a daily report, but he always replied that if he did not make it out every day he would soon try every possible means to avoid making out a weekly or monthly detailed report. As some daily idea is wanted of how the work is progressing, this report should be made out daily. It takes only a few minutes and when done is a great convenience to have to refer to; besides, a record like this is very valuable in case of lawsuit. Lawsuits cannot be always avoided. The sheet of paper is 8½ by 12 in. The lines ruled for records are ¼ in. apart. There are nine lines for the pay roll division, six lines for the material subdivision, five lines for the record of bills received and material ordered, and four lines at the bottom for the daily progress statement, which is continued on the back by reversing the sheet. The back is unruled.

The report is made out generally in lead pencil and a carbon copy made. The original is sent to the home office and the

carbon kept on the job. Such a report, it may be readily seen, lends itself to any job or class of work. If the job is large and divided into a number of classes or sections, then such a blank can be filled for each. It does not necessarily mean that all the details of a large job shall be crowded on to one small sheet if more space is areally required. The main thing is to have a record of all that is done each day, and have on the record enough information so that cost statements can be worked up from it and unit costs derived when wanted.



DAILY REPORT FROM .... (City) .... 19 ....

On Job .... For ....

Approved .... Supt. Const.

Weather .... Wind ....

Temperature

8 A. M. .... Noon .... 5 P. M. ....

Weather Indications Next 24 Hours

Daily Report must be mailed each evening, including Sundays and Holidays, using this form. If no work is done the fact, with reasons, must be reported. Give all information necessary to enable Home Office to keep in close touch with the work.
Accidents must be mentioned in this report and full particulars on separate sheet mailed in same envelope.
Troubles, Disputes or Disagreements must be mentioned in this report and full particulars on separate sheet mailed in same envelope

PAY ROLL						LABOR DISTRIBUTION and WORK DONE						
Number of Men	Hours	Rate	Amount	Occupation	Remarks	Number of Men	Hours	Rate	Amount	Class of Work	Am't	Units

MATERIAL USED			MATERIAL RECEIVED					
Amount	Units	Class	From	Kind	When	Car Numbers: Unloaded	Car Numbers: Not Unloaded	Remarks

STATEMENT OF BILLS RECEIVED

This statement refers to bills enclosed with Daily Report. All bills must be checked and forwarded the day received. Send copy if the original cannot be forwarded Get all bills in duplicate.

MATERIAL ORDERED

(Enclose carbon copy of order)

Date	Name	For	Amount	From	Kind	Estimated Cost	Date Expected

DAILY PROGRESS. State here fully the progress made this day, with amount of work done and give causes of delays, if any. Use sketches when necessary References must be made to drawings, maps, profiles, sections, etc., in order that progress may be noted on office copies.
Be brief but omit nothing essential. Use back of this sheet in preference to using two or more sheets of paper, turning over so ends will be reversed.

.... 19 ....
(Put Date on this line also)

FIG. 261.—Daily report.

The time to distribute the cost accounts is each day as the work is done. Records are made of delays and why they occurred. If high costs are encountered, the daily report shows why and how.

The writer, and every man engaged is this kind of work, knows that very few firms work up their cost records as they would have us believe they do when they read papers before societies on the subject. Much data is collected that is never made use of in the future. Elaborate blanks are often prepared

that fall into disuse a short time after adoption. Therefore the importance of having a plain, common-sense record of daily operations can be appreciated. Some firms do not want daily reports. Others go to the other extreme and want more than the one lone man on the job has any right to be expected to give, and instead of having a first-class foreman on the work, they make the bookkeeping part take so much of his time that they have a high-priced and incompetent accountant on the job, which is allowed pretty much to run itself. More complaints are received by the foreman about the poor way in which he sends in his reports than about the loss of money on the job through neglect of his work.

The pay roll deserves a section to itself, and another article will take up this important subject. For the average job on which a man will be sent away from home to manage, the common pay-roll books to be found in every stationery store will be sufficient. After all, it simply requires that the time of every man be kept properly. To avoid taking too much time in copying names, it is well to use on a weekly pay roll the 1-week books; on a bi-weekly pay roll the 2-week books, and on a monthly pay roll the monthly books. They cost 5 or 10 cts. each and fit nicely in the pocket. Such instruction seems elementary, but the writer has run across men whose books were so marked up because of the wrong blank having been started with, that a little elementary caution about pay-roll books seems necessary. When a job requires fewer than 100 men, the ordinary stock pay-roll book will be all right. It is only when a larger number of men are employed that something better is required.

The keeping of accounts on an ordinary contracting job is very simple. It is, however, absolutely necessary that the work required be performed every day. Five to ten minutes per day will do it, whereas letting it go to the end of the week or to any more convenient season means, very often, almost invariably, a quarrel with headquarters. Five minutes each day is a short time and can be spent after quitting time to advantage. The feeling of satisfaction coming with completed work is fine. Five minutes per day accumulates until it means half an hour on Saturday and many times means more than this, for the spirit that leads a man to put off the 5 min. makes him careless about placing his papers where he can lay his hands on them. Many

times the disinclination to do the 5 min. daily work has cost a man an afternoon and night of worry on Saturday or Sunday. In fact, if the work is let go until the end of the week, it is generally neglected until Sunday night, and then the Monday begins with headache and clouded mind.

The cash report has been dealt with as one of the items comprising the weekly report. Accompanying it should be all the vouchers, in the shape of receipted bills, cash slips, receipts for money paid, the pay roll and cancelled checks returned from the bank.

Bills paid by check from the home office are sent there daily, after copying in the bill record book. They are also noted on the daily report as shown. It is important that the bills be sent in daily so the home office can take advantage of cash discounts and bills paid locally should be met promptly for the same reason. This cash discount is an important item as affecting credits and profits, so some explanation may be of benefit to young men just embarking in business or on their first independent job.

The following explanation from Ryerson's Monthly can hardly be improved upon:

"A Cash Discount is a premium or inducement offered by a merchant to his customer to pay a bill before it is due."

Cash Discounts vary in the several lines of trade and their importance may be judged when it is stated that in some large concerns, the total profits at the close of a year's business are represented by the savings through taking advantage of all discounts.

Some houses have the terms and discounts fully and plainly stated on each invoice; others mark it, for example, "30—1–10," which means the bill matures 30 days from date, but if paid in 10 days a discount of 1% from the face of the bill may be deducted.

All progressive business houses take advantage of every cash discount that equals or exceeds the prevailing rate of in terest. The values of various discounts are:

60 days, less 2 %—10 days = Interest at 14 $^{10}/_{25}$ %.
60 days, less 1 %—10 days = Interest at 7 $^{1}/_{5}$ %.
30 days, less 2 %—10 days = Interest at 36 %.
30 days, less 1 %—10 days = Interest at 18 %.
30 days, less ½ %—10 days = Interest at 9 %.
30 days, less ½ %—for cash = Interest at 6 %.

To present it in another way. If you have purchased a bill amounting to \$300 on terms of 30 days—less 1%, if paid in 10 days and the prevailing bank rate of interest is 6%, you could make a saving of 12%, by borrowing the necessary amount from your banker and discounting the bill.

One % on \$300 = \$3; 6% on \$300 for 20 days = \$1; amount saved, \$2. Which equals 12% on \$300 for 20 days."

We thus see that in the course of a year considerable saving may be made and profits enhanced by discounting bills.

If discounts are taken, common honesty requires that payment be promptly made according to stated terms. If the discount time is 10 days, do not let it run over that time and then deduct it. The merchant feels, and justly, too, that he has been defrauded out of a portion of his profit. The consequent damage to the credit of the tricky purchaser is of greater moment than the small amount he may have gained by taking an extra 5 or 10 days to which he is not entitled.

The bills paid locally and shown in the cash report should be folded so they will be 3½ in. wide and be less than 9 in. long. On one end should be a memorandum giving date of bill, amount and name of firm. Receipts and cash slips on small pieces of paper should be pasted separately on sheets of regular letter size and folded and marked in the same manner. These vouchers should then be arranged in order to correspond with the items in the cash report so the clerk at headquarters may readily check the items. Put a band of paper about 4 in. wide around the bundle, leaving the written memoranda clear, and on the band write:

CASH VOUCHERS

Week ending..19....
.... Job
.... Foreman

This should be written on both sides, but is really not required except upon the side showing the memoranda on the ends of the folded vouchers.

The pay-roll report should not be enclosed with the cash report vouchers, as it is a separate matter, like bills paid from the home office. If the company has no special form for pay-roll report that shown by accompanying blank, Fig. 262, is a good one.

This form is used when men are paid by check or in some way not requiring the pay roll to be receipted. If the pay roll has to be receipted two more columns must be added: one to contain the name of the workman, the other that of the person in whose presence he was paid. This person should be some one besides the foreman, who signs the roll at the bottom as "Correct," so there will be two witnesses.

In arranging the pay-roll report put at the head the head man, letting each line hold the name of a man lower in position or authority than the preceding line, until the ordinary laborers are reached, when they will be placed according to number. In the columns giving rate of pay such an arrangement groups

PAY ROLL, Week Ending.................................19.................................

....Job at...

....Contractor ....Owner

No.	Name	Occupation	Rate		Time		Amount	
			Day	Hour	Days	Hrs.		

FIG. 262.—Payroll report.

men by pay and makes the report easy to check. In these columns use "ditto" marks instead of repeating the rate on each line. Never use "ditto" marks in the columns headed "Days" and "Hours" no matter how many men have the same time, and never use "ditto" marks in the columns headed "Amount." The pay-roll report should be in duplicate, the original sent to the home office and the copy kept on the job. It is well to make the report in lead pencil, using an indelible pencil, and have a carbon copy. Placing a damp blotter over the original will bring out the marks clearly and "set" them.

A regular order blank should be used for all material and as these blanks are stock forms carried by all stationery stores no particular form need be given here. No matter how unimportant the purchase, always make out a written order. If goods are ordered by telephone the written order should be mailed and marked "Confirming telephone order." Two carbons should be made of every order. The original should go

to the dealer, the duplicate be mailed to the home office with the daily report, and the triplicate be filed on the job to check the bills when received. It is understood, of course, that there is a letter file on the job in which to keep correspondence and carry papers. When bills are received they should be checked with the copies of orders and each order marked "Billed.................. 19....," to guard against a second billing for the same material. All orders should be numbered consecutively and in checking bills the order number should be marked against each item. If an order is spoiled mark it "Spoiled" and send the original to the home office to preserve the sequence, and file the spoiled carbon.

Never pay money without a receipt. Carry a receipt book always and have the receipts numbered. The stub is the job record and the receipt is sent in with the weekly cash report as a voucher.

Have the bank book balanced weekly. Check all cancelled returned checks on the stubs of the check book. With the weekly cash report send all returned checks to the home office. Arrange them according to number and date. Place around them a band of paper endorsed thus:

CHECKS RETURNED

Week ending.. 19....
.... Job
.... Foreman
.... Checks amount $........
Outstanding numbers..
amounting to $...

One or two pages should be ruled in the cash book giving the number of each check, the date and amount. A final column should give date check is returned canceled to home office. The foreman can thus keep track of checks issued and go after men who are disposed to keep them. No check should be out for more than a week. Payments the last week or two should be made in cash so matters can be closed up at the bank properly.

If the workmen are paid by check there should be a separate check book with another series of numbers. For example, the regular check book may begin with 1 and the labor account

check book may begin with 1001. A rubber hand stamp should be made for pay checks reading about as follows:

> This check is accepted as payment in full for labor and all services rendered to and including the date hereon, by the undersigned payee for................ on the ....job in the city of.......

the blank spaces, of course, in the above form, containing the proper names, as they could not be filled in with pen within any reasonable expense. That is, there should be a rubber stamp for each job. If the cost will not be too great the above could be printed on the back of each check. The place for this receipt across the upper end on the back so the first endorsement by the payee comes under it. With such a receipt it is unnecessary to have the men sign the pay roll.

When making the weekly cash report put the returned pay checks in bundles, having a wrapper endorsed:

PAY CHECKS

Week ending.. 19....
.... Job
.... Foreman
Amount of pay roll $..
Checks herewith $...
Numbers out...

The pay roll is, of course, the voucher for labor cost each week, but the following week nearly all the checks will come in and can be sent on, thus completely vouchering this item. The pay checks for each week should be kept separate even when there may be only one. When received at the home office the clerks there will collect them and by cleaning up every paper each week on the job the foreman is relieved of the worry of having several items to keep track of until each account is complete. At the home office there are men employed to keep accounts. The foreman on the job has merely to send everything they require in the way of information and send it in such a way that it will be clear to all concerned. He has no business keeping pay-roll checks until they all are in. He has no business keeping any papers relating to unfinished business. His desk must be kept clean no matter how the clerks at home growl. They have

the facilities for caring for the information and in proportion as the business grows the more thankful they are to have a conscientious, careful foreman on the out-of town job.

The accident report is something that must be attended to very promptly. All contractors carry some accident insurance and the companies are strict in regard to having reports made promptly. No time should be lost in making out the report and mailing it to the proper address.

In this particular considerable trouble arises. When a man is injured common humanity demands that such relief be given him as he requires. There must be no delay, for delays are sometimes fatal. Therefore, the foreman should have some bandages and appliances and supplies on hand for first aid work and should know how to use them. The aid should be given promptly and the injured man and his friends should be made to feel immediately that the boss sympathizes and is anxious to get him fixed right.

Owing to the insurance matters, however, we generally see a rather scared, and sometimes a badly injured, man sitting helplessly holding to the injured place while a lot of helpless looking men hang around waiting for the surgeon, and the foreman who should be competent to give some help, is worrying everyone with questions and showing about as much sympathy as Jack Frost shows for the tender bud in the early spring. So far as the men see, the boss cares nothing for the injured man but is merely intent on getting the information required by the insurance company. The men also know that there is nothing humane in the business at all but that the insurance company intends fighting the case at once. In the picture can be seen the seeds sown for a fight between the injured employe and the unknown corporation that has insured his boss against claims from him. Such things breed antagonism.

The things the insurance company wants to know about the man are simply his name, age, address, occupation, whether married or not and his nationality. When he is injured and scared, for all these strong fellows get terribly scared when hurt, it is heartless, to say the least, to annoy him and his friends with such questions, especially when they all know it is for the purpose of giving information to an indemnity company. The time to collect such facts is when the man is hired. There may be one hundred men constantly at work. Owing to the shifting con-

stantly going on there may be a total of several hundred men engaged upon the work during its progress and it is a bare possibility that none will be injured. Nevertheless it pays to keep all the statistical information ready for use when wanted. A man may be killed and his companions may not be able to give information when questioned. The class of lawyers known as "ambulance chasers" is annoying, and it often happens when a man is carried home that a representative of one of these harpies has been there already and the mouths of the family are closed tight.

The writer has on each job a small plain book with a couple of hundred pages. Each man has a number and it happens always that in the progress of the work several men will have the same number. Each page of this book has a number and he puts on each page the name of the man who has the number on that page. As each page has between 20 and 30 lines it is possible to keep a complete record of the names of men who have had the number. Following each name is put down the date the man started to work. The day he stopped may, of course, be put down, but it is not necessary and is often neglected. This book is merely an index to keep track of the names attached to the numbers.

For keeping track of the men he has small cards, 3 by 5 in., in a small pasteboard box with an alphabetical index. Such an outfit costs about 50 cts. The cards may be purchased with printing, on providing lines for the name, address, nationality, etc. These are stock cards. On the other lines may be put down whether a man is married, his age, number of children, etc. When a man is hired a card should be filled out with this information and the number he is given should be placed on the card. The date he begins is there also and these cards are very convenient to have to keep a record of the man throughout, if he is a man who may be good enough to attract the attention of the boss while he is on the job. Having filled this card it is filed alphabetically and on the book containing a record of numbers, the name is put down. When a man is injured it is just possible he can say nothing so he will be identified by the number attached to his clothing. By referring to the number record book, or to the time book, his name can be found and on reference to the card index his residence and accident insurance information will be found. These preliminaries being

out of the way it is possible to show the proper sympathy and give the man first aid. Promptness and efficiency in these two very important particulars have a wonderful effect on the men. After the injured man has gone the witnesses may be brought in one at a time, and their evidence obtained. The accident report may be filled out, the record completed on the card and the foreman is ready then for the next accident. In such cases it is highly important that three be due regard for common decency and everything possible should be done to avoid giving offense. Common laborers at such time feel particularly helpless.

Each foreman will have, of course, a book containing the names and numbers of the men under him. This book he is supposed to check with the timekeeper daily. It very often happens that the job is so arranged that the work can be attended to by the timekeeper alone and the foreman will not be required to keep track of the men. In the majority of cases when this can be done it is a decided advantage. If the foreman has nothing to think of but his men and getting the most possible out of them, he will do his work satisfactorily. When he has to keep a book, however, and makes entries in it, he loses much time.

The timekeeper should go over the job twice each day. In the morning between eleven and twelve and in the afternoon after four o'clock. His time book should be arranged with a page for each foreman and his men. The names of the men should be arranged consecutively by number. This will insure the least possible loss of time in getting the time.

On some work employing a certain class of men, and especially in large cities, the men shift frequently. In a city like Chicago, in certain sections, the common laborers seldom stay more than 2 or 3 days. They may work on the job several times a month but only for very short periods. The law requires that a man be paid in full when discharged, and these fellows generally manage to be discharged, for if they left voluntarily they would have to wait until pay day for their money. The obvious thing to do is to learn to know these men and after awhile decline to employ them. It often is the case, however, that men are not too plentiful and some of these fellows are really good workers when they do work, so it is well to ignore their peculiarity of wanting to draw their pay too often and

merely arrange the time keeping system so they can be kept track of. Here is where the number system is awkward and sometimes to oblige the timekeeper and to simplify his work, good men are refused employment after they have quit several times. It is not always possible to save numbers for such fellows. The writer makes it a rule to avoid duplication during each pay day interval. That is, if pay day comes each Saturday, a number will be given only once during the week. If pay day comes twice a month, then the number is given out only once in the 2 weeks. Such systems cannot be always followed if one has a small supply of numbers. On a job requiring 100 men there should be about 300 numbers to carry out such a system. The writer generally figures on having about twice as many numbers as he has men on a job constantly employed and then giving out a particular number only once between pay days. It has happened in seasons of the year when the weather conditions were very bad and there were frequent lay off periods, that such a supply of numbers was not sufficient. This occurs in large cities, as a rule where work is being done in the vicinity of large industrial establishments where indoor work may be had. The common laborers will do their best to secure an indoor job as soon as bad weather comes on and will hang around the big establishment until their money is gone before applying for an outdoor job on construction. So it often means that after a couple of days' lay off almost an entirely new gang has to be hired. The matter is complicated often by some of the older men turning up some morning and getting their number in the first 7 o'clock rush, and thereby causing lots of trouble when the new man who has that number comes in 2 min. later and demands it. Such little problems the timekeeper must wrestle with and get up schemes to make his work as easy as possible.

The writer used for years on his work a silicate slate book. These books may be obtained at almost any stationery store and have four, six or eight pages, ruled in lines for names. On the right hand edge rule a line and put down the numbers in ink. An acid ink is best. On the line opposite the numbers put the names of the men in lead pencil. By dampening the finger the name may be readily erased and when the man goes off the job his record will be completed in the time book and his name erased from the silicate slate. On the line opposite the number put down the date on which that number may be

again allotted. When the number is given erase the date and put down the new name. On the left hand edge of the page is to be ruled a column in which may be entered the time daily.

The advantage of such a book is that the time may be obtained on a job very rapidly and with the least number of mistakes. Every man is supposed to have conspicuously displayed a numbered badge. When the timekeeper goes out for the time he can stop each man he comes to, regardless of where he finds him, and turning to the number in his book ask the man his name. If it agrees with the name there he checks the time and goes on. After a while he, of course, learns the names of most of the men. It is an easy matter to check all the men after going over the job. If some have been missed the fact is discovered before returning to the office and the particular numbers can be hunted for. This is very much better than taking the time from a foreman's book. It eliminates favoritism and occasionally a foreman will put a man down as working merely to save time for himself, when the man may really be soldiering in the brush.

Upon returning to the office the time is transferred to the time book. On going out in the morning the men entitled to full time are checked off with a vertical mark. If only part time the number of hours will be set down. In the afternoon a cross mark will indicate full time. The transfers are made to the time book after the afternoon round. As each transfer is made the timekeeper must cross out on the slate, the time record for that day. After all the entries are made he should go over the slate very carefully indeed to see that everything has been entered properly, and thus avoid troubles on pay day. The only objection to this system is that the record taken on the job is erased and if an entry has been forgotten the workman will have a right to complain. Care, however, will prevent this. The writer in handling thousands of names in nearly 20 years of work has had so very few cases of trouble that he believes this system very good. Trouble will always come up about time, no matter what system is used.

An improvement on this system would require a slip for every man every day and the making of these slips would take too much time. The timekeeping must be done with a minimum of work. If ordinary time books are used the constant changing of the men makes it annoying and very often a timekeeper gest mixed on his numbers. By having the silicate slate book the

vacant lines always show at a glance the numbers available for new men and the dates on which they may be given out. Duplicate numbers on the pay roll can then be avoided and the pay roll easily made up on pay day for the report to headquarters.

Every man should have a number. Foreman and timekeepers complain that the men do not like to wear the numbers where they may be readily seen, and if not in plain sight much of the object of having numbers is defeated. A small, round brass tag with a hole to which is attached a strap is often given to the men, who hang it to a button hole like a watch fob. This is too low down on the person to be readily seen by the timekeeper and is in a place where the lifting of materials may tear it off. A number attached by a safety pin and worn on the breast is often knocked off when men have to lift heavy loads or climb to some position where they can work. The fact that the missing check is charged to them makes many men carry the numbers in their pockets and time is lost whenever they have to produce them for the inspection of the timekeeper. The writer believes it a good idea to have brass checks about the size of a silver dollar attached by a catch pin to the hat. Here it is out of the way and is readily seen. So far he has had few men object to wearing it there. The check should have not only the number on it but the name of the company. The men, of course, must pay for lost checks in order to teach them to be careful.

These systems here described are intended for the small contractor and the man who is sent from home and who for the time being is practically a small contractor. Large concerns will have their own methods and blanks and a book of instructions to guide foremen. Gilbreth's "Field System" is an excellent book for every man to own who is in charge of work. The way to obtain costs from the papers and books here shown will be given in the following article.

On the subject of paying men, a few words will not be amiss. If there ever was a fiendish invention devised to keep contractors and their men apart it was the invention of the payment of common laborers by check instead of in currency and coin. It saves very little work for the timekeeping department and is a most inhumane proceeding. The writer never does it if permitted to do otherwise. The men feel awkward in going to a bank. No matter how considerate the bank officials may

try to be, offense is easily given and very often a supercilious young fellow irritates the poor, ignorant men who go in. The question of identification is something that must be attended to and the bank officials, working on salary, cannot take too many chances. All this is very bewildering to the men.

Banks close earlier in the day then the workmen get off, so they must go at noon to cash their checks, and oftentimes they stay longer than they should. If they cannot get off to cash the check they have to go to a storekeeper.

In paying money to the men it is well to know that nearly all of them owe a little money to the stores at which they trade. If they are paid in bills of large denomination and go to a storekeeper he will keep his debt out of it. If they owe nothing at the stores it is almost impossible to get any bill larger than five dollars changed, and frequently the small storekeepers with whom such men trade cannot change a five-dollar bill. They do a small cash business in which the amounts seldom run higher than 50 cts. and they have very little money on hand. In fact, in many sections it would not do for the storekeeper to let his customers know that he keeps more than a few dollars on hand.

In paying men, therefore, a rule should be adopted to the effect that no man will receive a bill larger than $5 and that no one bill shall amount to more than half the total pay, and that not more than half of a man's pay shall be in one bill. If a man, therefore, earns $11, he will receive one five-dollar bill and the rest of the money will be in small change, and small bills. If he earns $9 he will not receive a five-dollar bill, but all his pay will be in small currency and change. By adopting such a rule the writer on several occasions has kept his gangs filled when other firms who were careless of the men's feelings had difficulty in keeping a full force at work. The day has gone by when the workmen on a job are to be considered merely as so much machinery. So far as the personal relations go, they are machinery, and to recognize the human element too much lowers efficiency. By treating them humanely, however, they respond very quickly. In no way can sympathy be more quickly established between the workmen and their foreman and employers than by treating them on pay day as if they were getting something they were entitled to. They feel they have earned their money and resent any lack of feeling on the part of the

timekeeper and the paymaster. The writer on pay day has the watchmen and foremen keep the men in line and accompanies the paying off with badinage and jokes as the men file by. It is easy to do and they stand around cheerfully. Too often on pay day the men are yelled at and treated disgracefully. It is as easy to grin as it is to scowl, and grins are always reflected. So are scowls. The writer has never yet witnessed a pay day when loud yelling and brutality on the part of the men who keep the men in line was justified, yet he has witnessed it many a time. Not that it is common on the majority of jobs, but it is unfortunately too common simply because of the attitude of some men being like that of the policeman who apologized when he hit a man by saying, "No offinse, sur. I don't bate ye because I hate ye, but ye see I have de autority."

The methods taken up in the preceding articles are accounting methods pure and simple. They show merely how the man in charge on the job reports to headquarters all his doings day by day so the accounting department can attend to its business properly.

On the daily report is a section devoted to the distribution of labor cost. This cost is obtained by making trips over the work and ascertaining as closely as possible what each man is doing, and such data are obtained readily when the timekeeper makes his rounds. It is not necessary to split cents on this matter. Each foreman can give a pretty good account of what he has been doing with his men. These costs will be distributed after the collector gets back to the office.

Bearing in mind always that large concerns will have their own methods and that blank forms will be supplied on which to collect and report this information, the methods to be adopted by the foreman in charge of work for small concerns can be his own methods, changed, perhaps, for each piece of work.

A blank book ruled in squares, six, eight or ten to the inch, as may be desired, is a handy thing to carry round. It becomes a regular diary and entries are made in it irregularly day after day. That is, when going over the work and certain piece of work is going on, a stop can be made and the movements of the men studied and their work timed. The notes can be made in the book, and as it grows it becomes very valuable.

The writer has found a small case holding about 15 or 20 3 by 5-in. cards a handy thing to carry around on work. The

cards are ruled and at the top of one will be written a heading and a date. For example, one card has on it, "Erecting gin pole on Sumach Creek Power Plant, Aug. 15, 1891." On the lines underneath are data telling the size of the pole, the size and length of the ropes used as guys; the number of men employed, the tackle, and what the pole was erected for. Some account was given of performance. Under the Gin Pole index in the file will be found a number of cards relating to gin poles on different jobs.

A series of cards relating to Derricks, Engine Setting, etc., will be found also in the card index file carried by a man who has been busy in such work for a term of years. This is the sort of data wanted by the foreman. To be sure, a pretty good knowledge grows on such matters and that is why experienced men are more valuable as a rule than inexperienced men. Under the modern system of ticketing information the new man gains over the old very rapidly.

Labor is the hardest thing to estimate on any work. It is the largest item on work generally. Because of the uncertainty of the labor item many contractors go to extremes in the purchase and use of machinery. A contractor may become "machinery poor," just as a farmer may become "land poor." The reasons are the same in both cases. The ignorant farmer, unable to make a decent living on a small farm, buys more land until he can hardly earn enough to pay taxes. The more intelligent farmer concentrates his efforts on a small place and gets along well. A contractor who does not know how to handle men properly, or who does not keep up to date on methods and whose knowledge of costs is not allowable of analysis, sees himself falling behind and blaming it on the labor, buys machinery until he is too heavily loaded.

Old contractors are fond of telling of the times when a sewer contract, for example, having been obtained, the contractor hired a gang of men and they needed no foreman. Each man knew his place and the work proceeded finely, the contractor visiting it only occasionally. Nowadays the labor is always ignorant and the best of supervision is required. Wages have gone up and prices have come down. The remedy is obviously machinery. This is the remedy in some cases, but not in all, and the incompetent contractor cannot differentiate.

Here is where the man with accurate cost and method data

comes in as a useful member of society. The writer has seen a great many notebooks of contractors of the old school, and he found very little matter of value from their own experience. Their notebooks were full of clippings. They sneered at books and book men and yet cut clippings freely from papers and saved them for reference. They talked glibly of letting prices, but knew little about "doing" prices. They knew vaguely that certain prices could be bid for work and there would be a "fair profit." The words "fair profit" were overworked and the legal profession still likes the term. Within a very few years the man with well filled notebooks containing records of work he has been in charge of and work with which he has been connected, is in demand. The writer last year was talking with the president of a contracting company whoc was bitter in his denunciation of the publication of "method and cost" data, yet who kept for several months an advertisement standing in a number of papers for a man with records of work covering not less than 10 years. His company wanted a chief engineer and manager with written records of not less than 10 years, work in a variety of employment, and he would employ no other. Yet he was angry because of the fact that methods and costs are things taught in engineering schools, and talked feelingly of the good old times when foremen and contractors were born and not made. Personally the writer prefers the manufactured article.

The previous articles tell the young man how to do the clerical work that goes with every job, so he will make a good impression at headquarters. This article attempts to show him how to secure the data he requires for himself so every particle of experience will be of value to him always. It is not so easy to do it. How can he do it? Each job is an experimental laboratory. Professors and investigators make experiments on materials and the designer works from very meager data very often, but relies implicitly upon it. The contractor must do the same. Costs are of value in proportion as the conditions are stated. It has been said they are of value only to the men who collect the data, but if they are of value to the collector alone, something has been gained by the collection and compilation. He is a better man for his observations and deductions. His methods will improve with his knowledge of costs, for the two are interwoven. Good methods mean lowest possible costs, and low costs can be secured only by following good methods.

Take the gin pole, for instance. Records of a dozen jobs on which gin poles were used showed that the last three or four gin poles were erected in less than half the time of the first. On the first job the young observer saw his first gin pole raised. The foreman of the gang and his men had raised gin poles before. On the next job the foreman was also an old hand, and the young observer had nothing to do with it. On the third job he noticed a little wrinkle and put it down approvingly. Finally we come to jobs where he is a foreman instead of a timekeeper, and one job shows how he put up a gin pole with some experienced workmen and some ignorant laborers. The last three jobs he erected gin poles himself as foreman with laborers from the south of Europe who did not know English and who were green at the work, yet the time was ridiculously short as compared with the first job observed, and, of course, the cost was low. He had learned. It had covered a period of 15 years and during that time only a few occasions had arisen for this particular kind of work. If it had been left to the treacherous memory to record, no record would have been broken. As the facts were recorded, however, with sketches, it was an easy matter to refresh the mind when such a piece of work came up and the experience of others summed up in his experience produced results with which his employer was well satisfied. Now, as he went at the work in a proper and methodical manner, who can doubt that his men did not have something added to their stock in trade of methods and costs. Suppose he published the facts and showed how he did it. We can believe that every man who reads it will know better how to erect a gin pole and even if he does not have one to erect today he can file the information in something more durable than the brain tissues and have it ready against the time he needs it

In this manner the young man will collect his cost data, remembering always that good methods and low costs are so intertwined that they cannot be separated. This is why published cost data are valuable. If the costs are very low, there must be a reason. If due to good methods, then there has been a distinct advance knowledge for the men who work. If the costs given are low because a mistake was made in omitting some items, these costs are subjected at once to a rigid analysis by men who know and there results another gain.

Some years ago, and it was not so very many years either,

a man was employed because he knew how to handle men. That was always the sort of man wanted. Today the average employer wants a man who knows something about costs and is well versed in methods. It is the same kind of man after all, but the employers have learned. The man they employ has become methodical and therefore is a better and stronger man. He knows how to handle men because he knows so well what a certain price of work should cost and knows so well the best methods to save time and motion, that the men respect him. Formerly the foreman had worked his way up from the gang and was obeyed because of the success he had made, yet his men were free to criticize many times where their experience had been perhaps slightly better than his. The trained foreman of today commands their respect because of the unhesitating manner in which he goes at things and because he knows just when to come back to view the finished job.

Like timekeeping and bookkeeping and the making of daily reports, the young man in a responsible position and the older man in charge cannot spend so much time hunting for method and cost data that they neglect their work, which is to keep the men moving and the job going at fever heat. They are there to obtain for the boss the most work at the lowest cost. He does not care whether they collect cost data or not. If he wants it he is willing to pay a man to collect it. He wants them to get the work out of the men and machinery and to obtain for him the largest possible profit on the job. Every minute spent on the collection of cost data that can be employed in looking after the job is a minute of his time lost.

Everything is useful. If a tab is kept of the time of men going to the storeroom for tool supplies and it can be shown that economy can be effected by putting in a couple of messenger boys or even installing an intercommunicating telephone system, then the time spent in observing this detail has been well spent. If a few minutes spent in watching the moving of a derrick results in the saving of a half hour on the next change, then the time has been well spent. What the eager seeker after knowledge must guard against is the habit of collecting data to such an extent that a man degenerates into a collector of data and nothing else. The writer knows men who can reel off costs by the yard and by the hour and who know all about the best methods of doing work, yet they are peculiarly helpless in directing men

in the doing of these things. Such men are spoiled in trying to manufacture a foreman. Yet such a man on a job to help out a born foreman is an experiment worth trying. It was done on one piece of work where a good hustler was sent to help out such a man. The hustler knew how to keep men moving without false motions and the other man knew the motions. It was an ideal combination, for which the hustler, however, got no credit finally. He is still working as a foreman and the other fellow is president of a contracting company.

The collection of data is important and the study of methods is important. The good man will learn to strike a balance and not neglect his work, while getting data from it that will be of service on succeeding jobs.

However, it must be said that just as it is necessary for the accountant to know every item of expense entering into a contract in order to strike a balance between expenses and income, so is it necessary for the man in charge to know unit costs and how to obtain them. Too much nicety in getting them is as bad as too much carelessness. The segregation of unit labor costs and unit material costs may really be made very broadly on the general run of work. A close study of all the operations connected with the conduct of the work and especially things that take gangs temporarily from straight work, will well repay the student.

Hourly Report Sheets Used in Tunnel Reconstruction.—The Washington street tunnel of the Chicago Railways Co. was reconstructed by Geo. W. Jackson, Inc., of Chicago. The forms, Fig. 263 and Fig. 264, were used to record the hourly progress of the work of excavating and concreting. With these forms the necessary data to plot progress and cost curves was supplied. They also gave a close check on the men, thereby tending to speed up individual effort, and furnished a complete, detailed log of the work. During the progress of the work the hourly reports were made out and telephoned to the main office.

A description of the work in an article published in *Engineering and Contracting*, April 20, 1910 supplied the forms referred to.

Rules for Construction Superintendents and Foremen.—The Construction Section of the National Safety Council, Chicago, has issued the following "safety first" rules for superintendents and foremen:

First Convince Yourself that accident prevention is worth

while. It reduces accidents 75% or more, it reduces labor turnover, and increases efficiency. Others have obtained these results on jobs both large and small; resolve that you will obtain them on your work.

Get the Men to Think and Act Safety. Instruct all new men

Shift No.

Shaft No.

HOURLY REPORT—MINING

Contract No.

Date 1910

Time.	Cars to Scow	Speed of Compressor	Air Pressure at Compressor	Headings.	Feet Driven and Lagged.	Feet Driven and Lagged Before.	Total.	Forms Set Up.	Miners	Number of Men.	Nature of Ground.	Remarks.
				No. 1								
				No. 2								
				No. 3								
				No. 4								
				No.								
				No.								
Total												

Accidents

Foreman.

Timekeeper.

	Yesterday	This Date.	Increase.	Decrease.
Total No. of Men				
Total No. of Cars Delivered Scow				
Total No. of Feet Driven and Lagged				

Scow No.

Scow No.

Scow No.

Weather

Miscellaneous.

Recapitulation of Employes.	
Foreman	
Timekeeper	
Elevator Men	
Lock Tenders	
Engineers, Civil	
Skinners	
Car Pushers	
Miners	
Muckers	
Dumpmen	
Engineers	
Carpenters	
Laborers	
Miscellaneous	
Electricians	
Total No. of Men	

Signed

FIG. 263.—Form for hourly report of excavation.

in safety when they are hired. Appoint safety committees and safety men. Install safety signs, warning signs, and safety bulletin boards. Invite the men to suggest safety rules and cautions. Stimulate the instinct of self-preservation.

Use Safe Methods in Doing the Work. See that all safe-

guards are used, that materials are safely moved and well piled. Do not overload equipment, floors, falsework or scaffolds. Keep passageways open and the entire job clear of rubbish. Do not let bolts, nuts or small tools lie around to be knocked off or tripped over, nor boards with projecting nails

Weather................
Shift No.................
Shaft No.................

HOURLY REPORT—CONCRETING.

Contract No. ....
Date.................................1910

Time.	Cars of Concrete.	Speed of Compressor	Air Pressure at Compressor	Material Used			Headings.	Cars of Concrete.	Feet Concreted.	Feet Concreted Before.	Total Concreted.	Number of Men.	Remarks.
				Gravel.	Cement	Sand.							
							No. 1						
							No. 2						
							No. 3						
							No. 4						
							No.						
							No.						
Total													

Accidents ....

....Foreman.
....Timekeeper.

	Yesterday.	This Date	Increase	Decrease.
No. of Men				
No. Feet of Tunnel Concreted				
No. Feet of Tunnel Plastered				
No. Cars of Concrete				
No. Yards of Gravel				
No. Yards of Torpedo Sand				
No. Bags of Cement				

Miscellaneous.

Recapitulation of Employes.	
Foreman	
Timekeeper	
Elevator Man	
Lock Tenders	
Engineers, Civil	
Skinners	
Car Pushers	
Miners	
Muckers	
Dumpmen	
Engineers	
Carpenters	
Laborers	
Miscellaneous	
Electricians	
Total No. of Men	

Signed ....

FIG. 264.—Form for hourly report of concreting.

to be stepped on. Permit no one to stand or work under a load or to ride a load being hoisted, and do not hoist a heavy load with a horizontal boom. Prohibit horseplay and practical jokes and see that they are eliminated. The public should be excluded from the job. Do not let any one take a chance.

Use Good Tools and Equipment. Inspect frequently and keep them in good condition. Guard all gears, pulleys, belts, electrical apparatus, etc. Provide goggles when needed to prevent eye injuries. Remember that the goose neck and gudgeon pin are the critical points of a derrick. Discard all poor equipment at once. The strength of guys, hoisting lines, ropes, blocks, hooks, chains and slings and their fastenings should be beyond question. Keep tools sharp and handles and striking faces in good condition.

Use Good Timber, Well Framed and Sway Braced for false work, scaffolds, shores and temporary supports. Prevent falls and injuries from falling objects by providing hand rails, toe boards and wire screens around elevated structures, scaffolds, openings and pits. Keep ladders and runways in good condition.

Do Not Work if Conditions Are Unfavorable because of high wind, poor light, storm, heat or cold, etc.

Fit the Man to His Job. Do not let a reckless, drunken or sick man work for you.

Be Vigilant. Instruct your men to be watchful for the safety of themselves and fellow-workmen.

Be Prepared for Accidents. Secure a first aid kit and learn why and how to use it. When starting a job find out about doctors, hospitals and ambulances and post the information near the telephone. Learn the prone pressure method of resuscitation from drowning, asphyxiation and electric shock. Treat all small cuts and scratches to prevent infection.

Ask Your Home Office or the National Safety Council for assistance if you need it. They will gladly give suggestions that will assist you to solve your safety problems.

TEN RULES FOR FOREMEN

The following rules are from a bulletin of the National Safety Council:

Be fair. Have no favorites and no scapegoats. A foreman has to act as judge many times every day; therefore, he must be just.

Make few promises and keep them. A foreman must be exact in this particular. Sometimes a foreman forgets that his job requires a high standard of truth and honor.

Don't waste anger—use it. Anger is valuable and should not be used carelessly. Keep your most forceful language for special occasions.

Always hear the other side. Never blame a worker until he has been given a chance to give his point of view.

Don't hold spite—forgive. When you have had to scold a worker, go to him later and show him his faults in a friendly way.

Never show discouragement. Never let yourself be beaten. A foreman must have perseverance and the "never say die" spirit.

Notice good work as well as bad. Let the workers see that you can appreciate as well as condemn.

Watch for special ability. Take a keen human interest in your workers. Put each one where he can do his best.

Take your full share of blame. This is the most difficult of all. The foreman who can share both blame and praise with his workers has discovered the secret of managing men.

Prevent accidents. Educate or eliminate the careless man. The good foreman is known by his men.

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